The AMSAT® Journal

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Phase 3D Team Meets to Review Ongoing Progress

Members of the Phase 3D Team met in Marburg, Germany from October 12th to 23rd, 1994 which included a "top to bottom" review of progress on all the satellite's systems and subsystems. During the discussions team members also bench-tested a number of flight-hardware electronic items and set the final operating frequencies for the spacecraft's transmitters and receivers.

"It was a marathon session" said Dick Jansson, AMSAT-NA's Vice President for Engineering. Dick went on to note that, as a result of the session, team members were now very confident that all key elements of the project were on schedule and the spacecraft's integration in Florida can continue without interruption.

Several critical schedule milestones were reached during the meetings. Among them were completion of all the formal documentation accompanying AMSAT's "Application to Use Ariane" along with the necessary safety submission. Together, these documents constitute the formal written request to the European Space Agency (ESA) regarding how AMSAT proposes to safely mount Phase 3D on the Ariane 5. A representative of ESA visited with the team in Marburg during the session to discuss details of Phase 3D's interface.

Also present at the session was Freddy de Guchteneire, ON6UG, Phase 3D's frequency coordinator. Under Freddy's guidance, the team finalized all of Phase 3D's frequency passbands. This important step cast the frequencies in "quartz" for the spacecraft's RF units. Complete details of the transponder frequencies will be provided in the next issue of the *AMSAT Journal*.

All present at the meeting agreed that the Phase 3D schedule was "tight". However, in closing, Dr. Karl Meinzer, AMSAT-DL President and Phase 3D Project Team Leader, expressed confidence that the time allotted for all remaining critical activities in the project schedule appeared both realistic and achievable.

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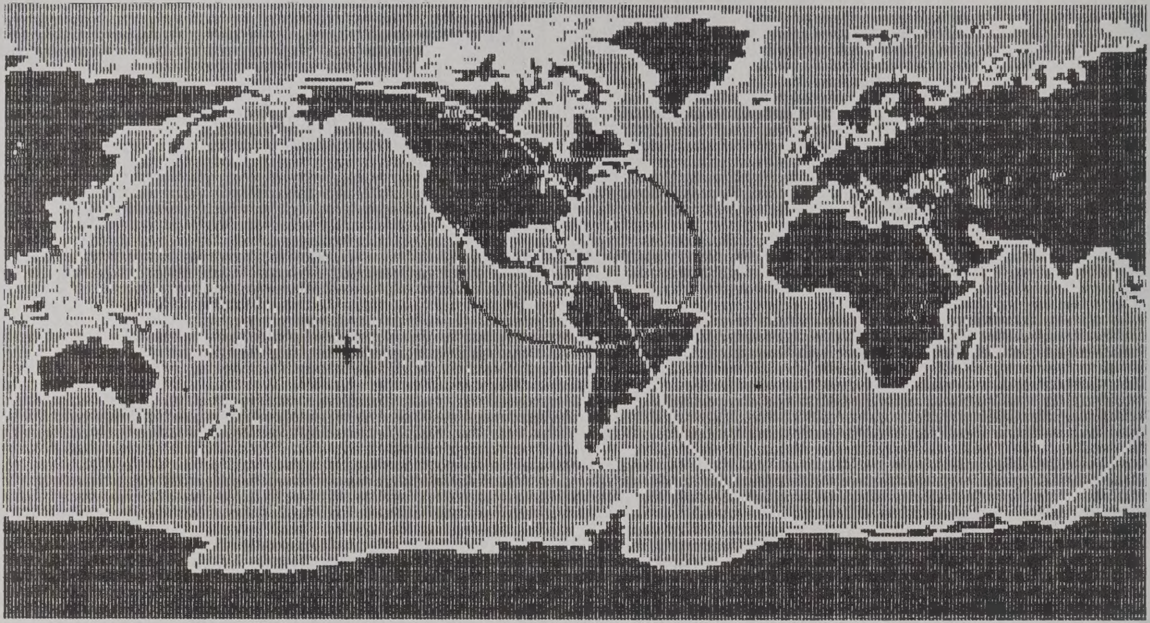

The **Kansas City Tracker** is a hardware and software package that connects between your rotor controller and an IBM XT, AT, or clone. It controls your antenna array, letting your PC track any satellite or orbital body. The **Kansas City Tracker** hardware consists of a half-size interface card that plugs into your PC. It can be connected directly to Kenpro 5400A/5600A or Yaesu G5400B/G5600B rotor controllers. It can be connected to other rotor assemblies using our Rotor Interface Option.

The **Kansas City Tuner** Option provides automatic doppler-shift compensation for digital satellite work. The **Tuner** is compatible with most rigs including Yaesu, Kenwood, and ICOM. It controls your radio thru the radio's serial computer port (if present) or through the radio's up/down mic-click interface. The **Kansas City Tuner** Option is perfect for low-orbit digital satellites like the NOAA and Microsat satellites.

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Apogee View

Looking Ahead

Guest Columnist: Keith Baker, KB1SF
With an introduction by Bill Tynan, W3XO

Apogee View is written, this time by our new Executive Vice President, Keith Baker KB1SF. Keith is the perfect example of one who has seen the need for actions that our organization should take, and then gone out and did something about it. I first met him at the AMSAT booth at Dayton. This rather brash young Air Force officer came up and bent my ear about all of our shortcomings and how we should do thus and so. I responded in my usual fashion. "We welcome all the help you and any other members can provide." Keith took up the challenge and started doing things. One of his most notable accomplishments was producing the book "How to Use the Amateur Satellites". He also offered his training in project management to help keep the Phase 3D construction process on track. In addition, he saw the need for providing press releases to the various amateur and other publications and started doing the job. Coverage of our activities has improved markedly ever since. Last year, the Board asked him to undertake the task of looking into our future after Phase 3D.

With this demonstration of capability and enthusiasm, it was not a surprise when KB1SF was nominated and elected to the AMSAT Board of Directors. Thus, when Ray Soifer W2RS expressed a wish to not be re-elected Executive Vice President, I suggested to the Board that Keith fill that post. I believe that Keith Baker is the perfect illustration that "new blood" can rise to leadership positions in our organization. AMSAT is NOT closed to new people and new ideas. KB1SF is a recent proof of that. With that introduction, I turn this Apogee View column over to our new Executive Vice President, Keith Baker KB1SF.

Last year the AMSAT Board asked me to undertake the important task of helping them draft a strategic plan that would take us well into the next century. The task included a "top-to-bottom" review of our history and heritage, a long look at our current project (Phase 3D) and its broad implications for our future, as well as a look beyond this most awesome project.

As I do my best to fill some VERY big shoes recently vacated by Ray Soifer W2RS as Executive Vice President, Bill Tynan has asked that I also continue working on this "strategic look" into our future. What I've found so far in this search has been profound. However, what it offers us is both exciting and, at the same time, ever more challenging as we prepare to move our organization into the next century.

One facet of our heritage indicates that it has been a relatively few AMSAT individuals (rarely more than a handful) who have done most of the building and launching of our satellites. They've been supported in their efforts by a large majority of members who have traditionally donated time, money and/or materials and who then use what the experimenters build once it's in orbit. Our experimenters have continually pushed the technological envelope and, in the process, have devised many new ways for us to communicate.

Now, mind you, this "marriage" has not always been painless! Some of us have thought the pace of new innovation has been way too slow, while others, the operators in our ranks, resent the perceived and sometimes real "orphaning" of their satellite equipment because the experimenter's latest orbital creation makes what they currently have in their shacks all but obsolete.

On the other hand, the benefits of this approach have been great. For example, who would have predicted that there would be packet satellites now literally FILLED with users on every orbital pass, or that there would be a loud clamor for expanded Mode S time on AO-13 when these respective transponders were first conceived and launched by their builders? What's more, who would have ever dreamed that a project like our MICROSATS would lead to the birth of a whole new multi-BILLION dollar commercial aerospace industry now poised to launch literally hundreds of these small store-and-forward satellites into orbit?

So, as I see it, the challenge for our future is to look for ways to keep our satellite experimenters continually pushing the technology forward and actively working on the next generation of satellites. At the same time, however, we need to insure that what our experimenters invent and launch doesn't also bankrupt AMSAT's budget, as well as our own personal ones; nor require that satellite operators have a Doctorate in Applied Physics in order to use the new birds.

I believe our current Phase 3D project is a classic example of the successful blending of these two seemingly incompatible philosophies. Just the mechanical and thermal challenges the project has presented to AMSAT's engineers have been awesome. I'm now convinced it has turned into a far bigger technical (not to mention financial!) challenge than any of us ever imagined when we first signed up to do it.

Sporting new and far more powerful transmitters and receivers on virtually every satellite band available, along with a user-oriented digital transponder (which will be a first on such a high altitude bird) Phase 3D will revolutionize the way we operate on high altitude satellites. These advances will occur even while insuring the investment most of us have made will be protected. That's because most, if not all, of our present satellite gear will not become obsolete when Phase 3D is launched. Granted, we may have to add a few antennas or converters out on our towers to exploit many of the new frequencies Phase 3D will use. Nevertheless, those of us now already equipped to use Oscars 10 and 13 will be pleasantly surprised to find that our current equipment will work even BETTER on the new bird once it's up!

Now, there are some who will argue that we haven't pushed the envelope far enough with Phase 3D, particularly regarding its digital capabilities. To a certain extent, this is true. With the realization that the RUDAK-E experiment will not be available, the RUDAK-U that is expected to be completed in time, may not provide digital experimenters with all of the facilities to test some of the newer and more exotic techniques. Nonetheless, Phase 3D's RUDAK-U WILL provide the vast majority of our digital enthusiasts with capability far in excess of anything available to amateurs today. No matter how we slice it, folks, Phase 3D's RUDAK-U will represent a giant step forward, and form a most vital capability for a variety of digital applications.

But, while the Phase 3D project now occupies a central place in our thinking and will provide much enhanced communications capability, it is by no means "the end". Many of us in the AMSAT leadership who have been pouring our hearts and souls into Phase 3D have also now begun the slow and often painful process of looking beyond Phase 3D ... developing strategies to exploit what's now happening in the rest of the space marketplace.

For example, how might a wide-band (20 MHz) transponder in geostationary orbit riding piggyback on a commercial satellite be accepted by our experimenters and operators? With such a device, whatever is sent up to the bird gets "squirted" back down on the downlink ... in a footprint that occupies virtually half the Earth. The satellite is always there ... day and night ... in the same location. Uplink power would be about 10 watts, and ground antennas would be small dishes about a foot and a half in diameter. GONE would be the limitation of what the bird can accept and pass on in a more traditional "store and forward" digital application to which many of us have now become accustomed.

Gone, too, would be the limitation of the satellite's onboard memory to store digital information. An interesting added benefit of this approach is that under this scenario, the GROUND stations are the ones that absorb the burden of building and testing the "new and exotic" gear ... not the transponder builders. Unless I'm way off base, the applications for both new transmission modes as well as the opportunity and flexibility to accommodate both our experimenters and our more operationally oriented analog and digital users through such a bird are virtually limitless. What's more, preliminary estimates for an average user to get started using such a transponder indicate that a ground station would cost less than what we might spend for an ordinary VHF hand-held!

Now, if you think this all sounds like a clip from the TV series "Beyond 2000", think again. There's a prototype of such a transponder now being built for testing in the Amateur Radio Satellite Service as this edition of the Journal goes to press. It's but one of many "pipe dreams" we in the AMSAT leadership are actively exploring at the moment as possible follow-on payloads for as yet unspecified launch opportunities that might become available to us in the future.

Another "half-baked" scenario involves using one or more of the backup spaceframes we've already built for Phase 3D to build a follow-on (Phase 3-E?) spacecraft. However, this time we'd offer the space that's left over beyond the Amateur Radio payload to commercial, governmental and/or scientific interests in exchange for assistance with the costs of construction and launch. Another crazy dream? Absolutely! But, then again, so was Phase 3D when the idea of a "super OSCAR 13" was first discussed back in 1990, or when the concept of a MICROSAT was first put forth back in the mid-1980s. The above approaches are simply two of literally hundreds of innovative ways we might successfully build and launch new AMSAT payloads in the future.

Our work on the Phase 3D project has taught us that even with the solid backing of international partnerships and extensive fund raising campaigns, the days of relying on leftover space-qualified materials and low cost (or "free") rides to space for large, dedicated AMSAT satellites are rapidly drawing to a close. If we are to successfully compete in the world's emerging market-based space arena of tomorrow, it's imperative that we revolutionize our traditional thinking, and begin seriously exploring new ways to get future AMSAT payloads into space.

Fortunately, with scores of emerging commercial construction and launch agencies coming on line, we expect there will also be a corresponding increase in launch opportunities as we move into the late 1990s. However, unlike many of our past projects, where governmental or quasi-governmental agencies did our launches for us at "bargain basement" prices, we now believe future launch opportunities and costs will most likely be strictly market-based. Another challenge, then, will be to develop ways to exploit these new building and launch opportunities while at the same time minimizing (or avoiding) the ever-more-massive fund raising efforts and long-lead construction times that seem to have become the norm on many of our current projects.

That's where you, our loyal members, are going to have to really help us out as

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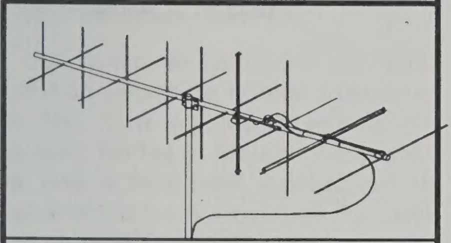

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we move forward into this new arena. The handful of us sitting in AMSAT's leadership positions simply don't have enough hours in our days to track down and exploit every potential launch or other opportunity that might possibly come our way in the next few years. Rather, each of YOU will have to truly become advance "AMSAT ambassadors" to help your leaders make those initial contacts into aerospace companies as well as into government agencies long since written off as "closed" to us. As in the past, we'll also need your help in building the flight hardware and software, as well as marketing AMSAT's most worthy educational and scientific goals to the leaders of potential launch organizations, proving to them that it's in their own best interests to have AMSAT riding along with them to space.

Put another way, simply suggesting to your AMSAT leadership what "AMSAT should do......" has always been welcome, but for the future, it is just not going to be enough for us to get new amateur radio payloads built and launched. Each of us is going to have to become far more innovative, creative and INVOLVED in all aspects of the conceptualizing, planning, building, launching and controlling processes for our future space endeavors. That is, your help is going to have to go well beyond just initial suggestions and ongoing financial support. This MUST happen if we truly want to see this part of our wonderful hobby continue beyond the Phase 3D project.

We have nearly 8000 of the world's most brilliant minds among our members. Each of you have impressive talents that could be applied to any aspect of our organization and the perpetuation of its goals. Others of you have solid connections in established or emerging aerospace organizations. If you've helped us out in the past, we offer our most heartfelt thanks. But if we haven't already, we'd like to now begin using your extensive talents and contacts to help us explore and perfect new and innovative approaches that will ultimately carry the dreams we all share for AMSAT into the next century.

I'm confident that Bill and I can count on each of you for your continued, personal support in the months and years ahead.

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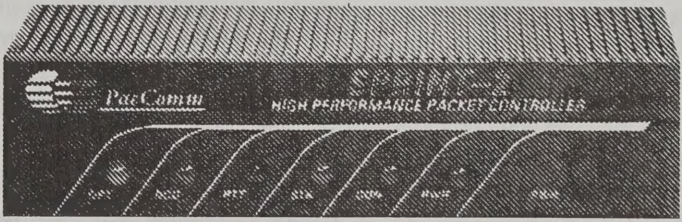
Packet Satellite Modems



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Inexpensive Automatic Control of Az-El Rotors

Charles A. Richard KM4EM,
James A. Sanford WB4GCS

Automatic rotor control of high gain antennas brings a number of advantages to satellite operations, including better received signal strength, lower transmit power requirements, and more data capture on the digital birds. It is also quite a bit easier on the operator. The unfortunate perception persists, however, that automatic control is either expensive (as in the cost of a commercially available tracking unit) or difficult (as in building from scratch). In fact, such a system can be easily built for under $100.00. Prairie Drive (PrrieDRV) is an automatic rotor control system, based on an inexpensive interface card (Prairie Digital Data Acquisition System). This card interfaces an IBM compatible PC to a Yaesu G5400B (or compatible) rotor controller. It is controlled by Terminate and Stay Resident (TSR) software which interfaces with most popular tracking programs. PrrieDRV.com honors the KCT interface standard[1], so it can be used with a variety of "parent" software programs.

Software

The PrrieDRV.com software executes three primary functions:

- initialization of the hardware
- installation of the TSR which emulates the KCT and interfaces with your tracking program
- installation of the TSR which actually measures current position and does the tracking.

Once initialization is complete, that code is discarded and its memory returned to DOS. In compliance with the KCT standard, interrupt 63h is used to interface to your tracking software. To accomplish the actual tracking, the DOS timer, interrupt 1Ch is used. To prevent adverse effects on DOS, its interrupt service routine is processed before the tracking routine is entered. The tracking routine was made as efficient as we could; feel free to improve it. We have seen no adverse impact on DOS or Windows in any of our tests.

The interrupt 63h function implements the following subset of the KCT specification:

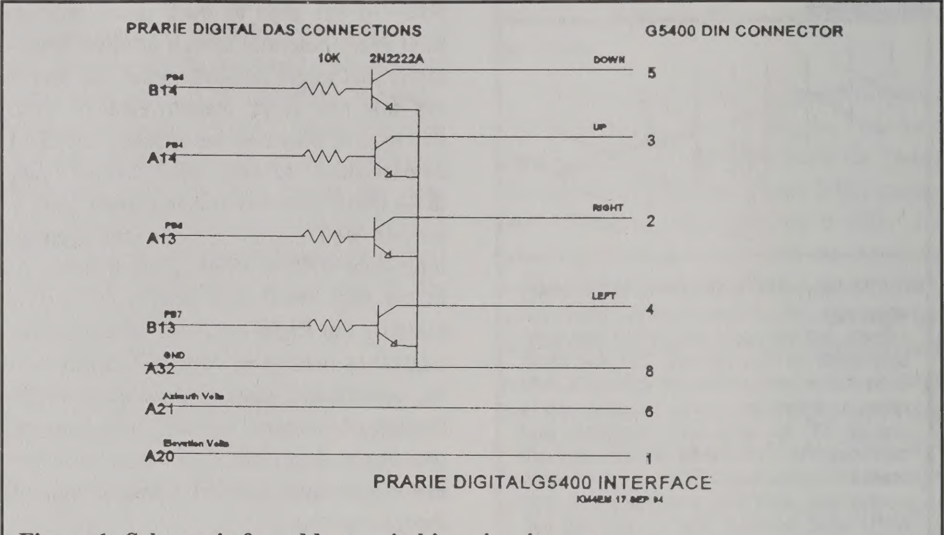


Figure 1: Schematic for add-on switching circuit.

- Set target rotor positions (AH = 4)
- Enable/disable tracking (AH = 9)
- Read current and target positions (AH = 3)
- Read current status (AH = 0)

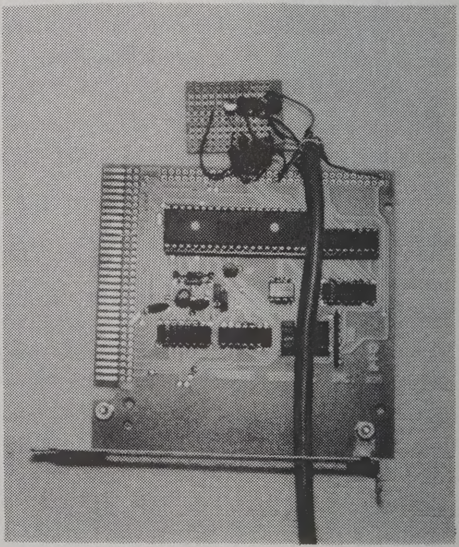
All other service requests to interrupt 63 are ignored. As required by the KCT specification, an attempt to set an invalid target position will be ignored. For more details on these services, see reference 1. After the interrupt 1Ch function services DOS, it first verifies that tracking is enabled. If not, nothing else happens and the interrupt service routine terminates. If tracking is enabled, the current rotor position is obtained, stored, and compared with ordered position. The azimuth comparison happens first, and if the azimuth rotor has not been reported as stalled, appropriate commands are issued.

Next, elevations are compared, and appropriate commands issued (unless the elevation rotor has been reported as stalled). Tracking system status is updated as soon as rotor commands are issued, so your tracking software can always get the current status by using interrupt 63h, function 0. As mentioned earlier, interrupt 63h interfaces with your tracking software to enable and disable tracking, as well as specify target positions.

PrrieDRV.com was designed to be called from a batch file in an automated station, so there are no menus or graphical interfaces. A few command line switches are available:

prriedrv </a<->0-9> </e<->0-9> </d0-9> </p> </s>

/a	specifies an azimuth offset which is algebraically ADDED to the TARGET azimuth.
/e	specifies a similar elevation offset.
/d	specifies a tracking "deadband" to prevent excessive "hunting". Default: 3 degrees.
/p	selects the alternate port address for the Prairie Digital Card.



Prairie Digital plug-in board with perfboard add-on that contains the switching circuit (4 transistors and 4 resistors).

/s causes the target azimuth and elevation to be displayed in the upper right-hand corner of your text screen. Actual position is displayed on the next line.

Options may be specified in any order, invalid arguments are ignored without report. Use of the /s option slows your system down but has not caused us any problem, even at 9600 baud. Azimuth and elevation offsets are limited to +/- 9 degrees to allow MINOR corrections for rotor aiming and calibration. PrrieDRV.asm was assembled using the Borland Turbo Assembler 3.0 and 4.0. We've tried to avoid anything unique to the Borland compilers, so we would expect satisfactory assembly with Microsoft or other assemblers. No others have been tested, however.

Hardware

The hardware portion of the rotor control system is centered around the Prairie Digital Data Acquisition System (DAS). This half-height card includes an 8-channel (multiplexed) 8-bit analog to digital converter, 24 bits of programmable digital input/output(arranged as 3 8-bit ports), and a user configured 12 bit CMOS counter (unused in this project.) The A/D converter uses a serial interface to the microprocessor via several of the digital I/O bits.

Each port can be configured as either an input or output; port C can be further divided into two 4 bit ports, individually configurable as input or output. Configuration of ports A, B, and C is set by a 4th control port. The card occupies four consecutive addresses, starting at (default) address 772 Decimal. Jumpers are provided to move these addresses to 644-647 Decimal. (The accompanying software assumes the default addresses, but the alternate address is available).

Ports A and C can supply 200 uA, or sink 1.7 mA, while B can supply 1 mA, or sink 1.7 mA. Port C, bits 3, 6, and 7 (PC3, PC6, and PC7) are used to control and transfer data from the A to D conversion chip. PB0, PB1, and PB2 select the analog input channel. Two A/D channels are used to convert the 0 to 5 volt output of the Yaesu G5400 rotor controller to 8-bit values representing current Azimuth and Elevation. Four of the digital I/0 channels command rotor movement. Based on the drive capabilities, port C was dedicated to A/D control, while port B was used for both analog input selection and rotor control. Port A is not used (and is available for such things as polarization switching, antenna selection, etc). A summary of Port allocation:

Port	Function
PA0-7	Not Used
PB0-2	Analog input multiplexing
PB3	Not Used
PB4	Up output
PB5	Down output
PB6	Right output
PB7	Left output
PC3,6,7	A/D control
PC0-2,4-5	Not used
X0	Azimuth volts input
X1	Elevation volts input

The only additional hardware required is an array of four simple transistor switches to match the TTL level Left/Right/Up/Down outputs to the G5400 inputs which are PNP transistor bases. Each G5400 input is grounded to command motion in its respective direction. Switching transistors (MPS 2222 or MPS 3904 etc.) are wired as common emitter logic inverters, with the control lines from the G5400 going to each collector, and the bases connected to the corresponding bits of Port B. (See Figure 1).

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Note that it does not take much leakage current in these transistors to actuate the relays in the G5400 controller. A batch of "NPN switching transistors" initially used was unsuitable and resulted in all four signals being asserted at once. Fortunately, the rotor protects itself from simultaneous grounding of both azimuth or elevation commands by giving priority to RIGHT and UP commands. (We observed this!)

The transistor switches were mounted on a small piece of Radio Shack perfboard. This board was then mounted to the Prairie Digital Card using the 10k resistors, and positioned to be in line with the card when mounted in the expansion slot. The connection to the G5400 used seven conductors of a shielded nine conductor Radio Shack cable. The Azimuth and Elevation voltage inputs to the controller card go directly to the Prairie card, as does the ground line from the rotor controller. A separate ground line from the switching board (from the emitters of the transistors) is also tied back to the Prairie card.

Installation and Calibration

After construction and wiring, insert the card into an unused expansion slot in the computer, and connect the cable to the G5400. Check the size of the DIN connector going to the G5400 prior to installation, as some will not pass through the typical expansion slot opening. Run PRRIEDRV with the /s option and your favorite tracking software. You should see the target and actual positions in the upper right hand corner of your screen. Now position your azimuth rotor to the right-hand stop and 180 degrees elevation (90 if you won't be using the "Flip" option in tracking). Adjust the calibration pots on the back of the G5400 for indicated position of 179 azimuth and 179 (or 89) elevation. (Make sure you adjust the REMOTE calibration controls, not those for the front panel meters). Release your manual override. Your system is now ready to go! Alternatively, you could load prriedrv with the /s option, then run something like SatSked, which will park your rotors in a certain position. Again, adjust the calibration until indicated position is correct.

Operation

Operation of the system is simple. First the PRRIEDRV.COM file is loaded, then ORBITDRV.EXE, then ITRACK or other "parent" software. An example batch file might look like (assuming all files were in the same directory named "track"):

```
CD\TRACK
PRRIEDRV
ORBITDRV
ITRACK KITSAT-A (or SS, RTC, etc)
```

See Reference 2 for more information on ORBITDRV and ITRACK. PrrieDRV has been tested with ITRACK, SatSked, InstantTrack, and RealTrack. It has been used in conjunction with PB/PG on 486DX/33 and 486DX2/66 computers with no adverse impact on downlink data. As it honors the Kansas City Tracker interface standard, it should work with any software that supports the KCT. Primary testing has been done under SatSked, which serves well as "parent" software, allowing specification of Rotor park position as well as allowing automatic calls to PrrieDRV. Since PrrieDRV.com has no way of knowing what other TSRs have been loaded on top of it to use interrupt 63, it has no way to unload itself. Disabling tracking returns most of the time borrowed from DOS, especially in the critical DOS timer interrupt. The TSR memory is still retained. To remove PrrieDRV.com from memory, you can reboot the computer, use a separate utility to remove TSR's, or run from within a DOS box in Windows. This last option runs slower, but has the advantage that when you close the DOS box (EXIT command) all TSRs are removed from the DOS "virtual machine".

Extensions

It would be nice to use Port A for other things around the station in conjunction with your satellite station automation. PrrieDRV.com was carefully written to allow this. The hardware is only initialized upon installation; after that everything is done by reading a port (word) and manipulating ONLY the bits of concern before writing the modified value to the port. With a similar technique, you could reprogram the CONTROL port to allow port A to be either an input or output. The process would be:

```
INTERRUPTS OFF
READ CONTROL PORT
MODIFY PORT A CONTROL BIT
WRITE CONTROL PORT
INTERRUPTS ON
```

If you're working in BASIC, you can probably get away without messing with enabling/disabling interrupts, since the CONTROL port is only modified once by

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PrrieDRV.com. Once PORT A is initialized as you want it, you can read/write it as often as you want, independent of what PrrieDRV is doing. See reference 5 for the control byte required.

Limitations and Availability

This low-cost implementation does have some limitations. The 8-bit A to D converter resolution results in an azimuth conversion accuracy of +/- 1.4 degrees, and an elevation conversion accuracy of +/- .7 degrees. Although coarse, this is less than the beamwidth of typical 2m and 70cm antennas and has not caused any problems in our tests. The TSR's do steal some processor time and may cause you some problems if you load lots of TSR's or multi-task in Windows. (We have not seen any problems in our tests, but it is possible.)

One note of caution: When Windows encounters certain errors (like trying to read from a floppy drive which isn't ready for some reason), EVERYTHING stops, including the timers. If this happens, your rotors will continue to execute their last command until interrupted by a thermal cut-out or limit switch. This potential problem is not limited to PrrieDrv, but can occur with many rotor drivers. Thanks to KB5MU for this exciting tid-bit!

The PrrieDrv software is available from KM4EM, as well as KO-23, AO-16 and LO-19. In addition it is available via internet on AMSAT-NA's ftp site. The software is distributed free of charge with no warranty of any kind for non-commercial, amateur use only. The Prairie Digital Data Acquisition System (Model 30) is available from:

Prairie Digital, Incorporated
846 Seventeenth St, Industrial Park
Prarie du Sac, WI 53578
608-643-8599 (v)
608-643-6754 (fax)

Our only connection with Prairie Digital the fact that we're satisfied customers.

Acknowledgement

The TSR software is heavily adapted, with permission, from DUMMYKCT.ASM, by Paul Williamson, KB5MU. Paul's generosity and assistance during the development of this project are gratefully appreciated. For questions or comments, the authors may be reached at wb4gcs@amsat.org, km4em@amsat.org or via KO-23, 25, AO-16 or LO-19. We hope you find this project as useful as we have.

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1. "Kansas City Tracker/Tuner Driver Service-Call Functions", Brooks Van Pelt, KB2CST, 21 Jun 88.

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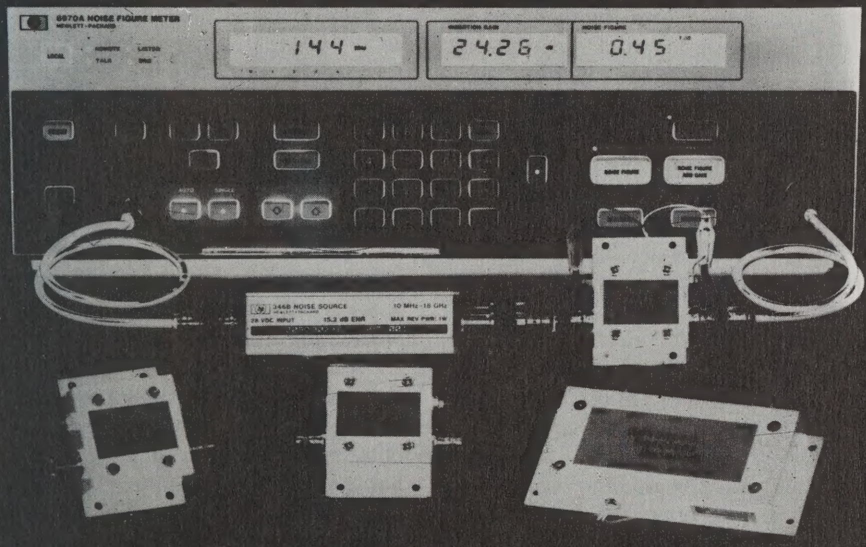

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P144VDA	144-148	<1.0	15	0	DGFET	$37.95
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P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
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SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
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SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

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Editor's Note: The following article first appeared in the March/Aril 1992 issue of the ***AMSAT Journal****. It is reprinted here as essential background for the accompanying article by Hanspeter Nafzger.*

An Alternative Approach to UO-14/UO-22 9600 baud Reception

By: Ed Krome, KA9LNV

An Afterthought, at the Beginning

The hardware on which this article is based was originally targeted toward reception of UO-14's 9600 baud downlink, and it performs quite adequately for that purpose. But one of the real values of the proposed arrangement will be for those computer imagery enthusiasts who are very interested in satellites (they take really neat pictures!) but don't have lots of fancy radios with which to listen to the birds. This arrangement is well suited to the development of a compact, inexpensive receiving station for UO-22's great pictures. Of course now that UO-22 is also the primary 9600 baud data satellite, the receiver can be used for that purpose as well.

9600 baud - the Soundless Signal

UO-14 is an amazing bird. Its 9600 baud digital mailbox transfers information at an almost unbelievable rate. The 1200 baud birds seem slow and ponderous by comparison. It is possible to capture over 800 kilobytes of data in a single 15 minute pass. Whole files seem to magically appear. So, the question quickly becomes: why isn't everybody using this bird?

For a starter, operating UO-14 is different. The 1200 baud Microsat's require an AFSK-on-FM uplink and transmit a PSK downlink, which is received using a SSB receiver. The interface between the ground station transmitter/receiver and the BPSK modem is normal hearing range audio.

When you tune across PACSAT's beacon, its chainsaw voice leaves little question that you are hearing a Microsat. UO-14, on the other hand, uses FM on both the uplink and downlink. But not your ordinary, garden variety FM. When you tune across UO-14's beacon, you can't even hear it! Its 9600 baud FSK signal sounds exactly like unsquelched FM background noise. One of the cruder ways of determining whether the satellite is really there or not is to run the receiver squelch control up high enough to completely squelch all noise. The UO-14 signal, if present, will break the squelch and its white noise will roar through.

Reception of this "soundless" signal is somewhat more complicated than plugging your modem into the receiver's headphone jack, and this is where many hams recoil in horror. Fig 1 shows a block diagram of the required equipment. Your receiver's audio chain, since it is optimized for narrowband operation, is quite effective at filtering out the received data. Your ear isn't the only thing that won't hear anything listening to the receiver's audio output- neither will your modem. The trick is to pick the signal out of the receiver FM signal path before it is processed by the audio stages. The only place to do this is right at the output of the discriminator. And, as they say, herein lies the rub. To access that unprocessed signal requires what can seem like major surgery on your radio. Many hams are somewhat hesitant to disassemble and go wandering around inside of their several thousand dollar radio, knowing they have to first find a single pin on an IC, then solder a wire to it. And to do so would probably not be looked upon kindly by the radio manufacturer's warranty administrator, should a problem arise, or by your friendly local (HiFi) service shop. So, if you are neither completely competent nor quite brave, you may elect to forget it! This is all, of course, assuming that you even have a radio capable of receiving 70cm FM.

Enter the Ramsey 10 Meter FM Receiver

Although radio surgery is not all that difficult (Yes, I have done several, and haven't lost a radio yet!), I decided that an alternative approach that didn't tie up the main rig was of value. Review of miscellaneous ham magazines showed a number of small FM receivers to be available. In particular, Ramsey Electronics offers a complete 10 Meter FM receiver kit for less than $30. So I bought one, reasoning that it could be used with a 70cm in-10 Meter out receive converter and might just do the job.

The Ramsey receiver is quite an interesting little beast, and quite a value for the price. Its 4 by 4 3/4 inch circuit board contains a complete double conversion superhet receiver, with a bipolar RF amplifier, an NE602 local oscillator/mixer, an MC3359P FM IF section/discriminator and an LM 386 audio amplifier. It will tune almost the entire 10 Meter band and works surprisingly well. The audio is plenty loud enough for all normal uses. But the audio wasn't my interest, data was.

Review of the schematic, see Fig 2, and the appropriate Motorola manual showed that the MC3359 has the discriminator output available at pin 10. So I soldered a wire to pin 10 and hooked it to my G3RUH 9600 baud modem. A homebrew 70 cm-10 Meter converter was attached to the Ramsey receiver's input and I waited for a UO-14 pass. Fig 3 shows the complete setup. And it worked!

Would you believe that it worked the first time! I cheated and attached an oscilloscope to the G3RUH modem's received signal monitoring points to observe the eye pattern and actually see what the modem was doing. Since you can't hear UO-14's signal, this is the most satisfactory method of knowing what is going on. The scope's display should show a clean "eye" pattern with even, symmetrical excursions and sharp zero crossings, see Fig 4. Correct tuning is simply a matter of tuning for the best eye pattern. The other, but somewhat less satisfactory method of determining whether you are receiving data is to watch your TNC's CON LED. It will flash on and off when packets are being received. Or, you can watch the computer screen and see if anything is actually being decoded.

How to make it work better

After monitoring a number of UO-14 passes with this setup, a few shortcomings became apparent. First off, the Ramsey receiver's wide tuning range makes peaking on UO-14's signal rather touchy and very difficult without

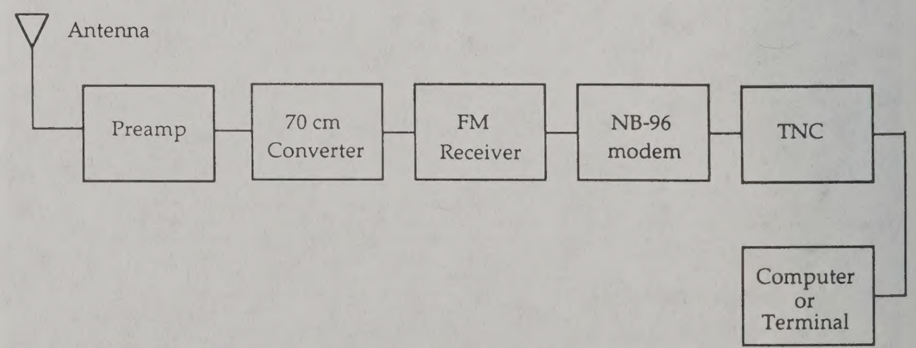

Fig 1: A block diagram of the UO-14 receiving system.

a scope. Second, since the Ramsey uses an unregulated voltage across a varactor diode to tune its Local Oscillator, the tuning will drift slightly as the battery voltage drops. It will also drift a little as the audio level is turned up and down, as that changes the current drain from (and voltage on) the 9V battery buss.

Both shortcomings are easy to overcome. Since this receiver kit is so inexpensive, I would recommend dedicating one completely to UO-14. The fixes are easy, consisting of reducing the tuning range to cure the first problem and adding an IC voltage regulator to the receiver's 6 volt buss for the second.

To modify the 10 Meter Ramsey FM receiver for UO-14, do the following:

1) Build and align the Ramsey kit exactly as per the manufacturer's instructions and insure that it functions properly.

2) Wire up the discriminator output tap. Mount a miniature phone jack (or some other shielded connector) on the rear panel of the receiver enclosure, preferably away from the RF side of the circuit board. Run shielded cable from the connector under the board. Solder the center conductor to pin 10 on the MC3359 IC. Ground the shield to a convenient point. This is not critical.

3) Decrease and broaden the tuning range as follows:

a) Solder a 68 pf silver mica or polystyrene capacitor underneath the board across the main tuning coil, L3. Since it is connected in parallel with the tuning varactor, it decreases the tuning range. It also appears to lower the Q of the tuning coil and therefore broaden its bandwidth.

b) Decrease the effective maximum resistance variation of the tuning pot R1 by, first, scraping away small sections of the traces under the board where they are soldered to the outside terminals of R1. Bridge each trace cut with a 1000 Ω, 1/4 or 1/8 watt resistor. Solder a 6.8K resistor across R1's two outside terminals. This reduces R1's effective value to 2.8K while maintaining a total resistance of 5K (same as the original) for the R1 plus resistors combination so the AFC circuitry still works as designed. The above two modifications will typically reduce the total available tuning range from almost 2 MHz down to less than 280 kHz. This greatly simplifies tuning.

c) Remove and replace R20 (270 Ω) with a 78L06 IC voltage regulator. The addition of a voltage regulator insures that the VCO buss will not vary with varying battery voltage. Underneath the circuit board, connect the 78L06's input lead to the now vacant R20 lead hole closest to the on-off switch. Connect the output lead to the other R20 hole and the center ground lead to the ground plane. To insure regulator stability, add a .01 disc capacitor between the regulator input pad and the ground plane. An additional benefit of replacing R20 with an IC

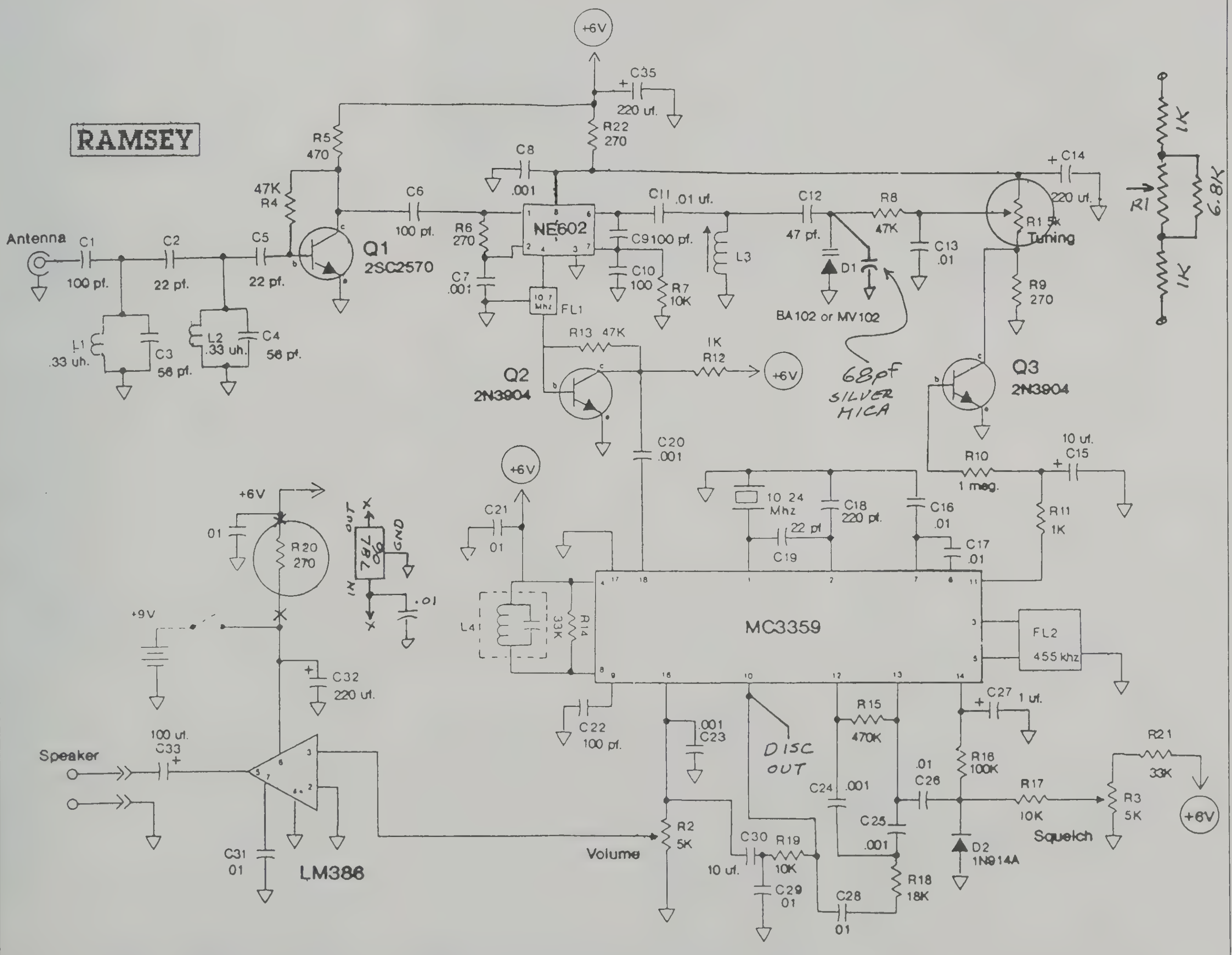

Fig 2: Schematic of the Ramsey FR-10 FM receiver (reproduced with permission of Ramsey Electronics, Inc.)

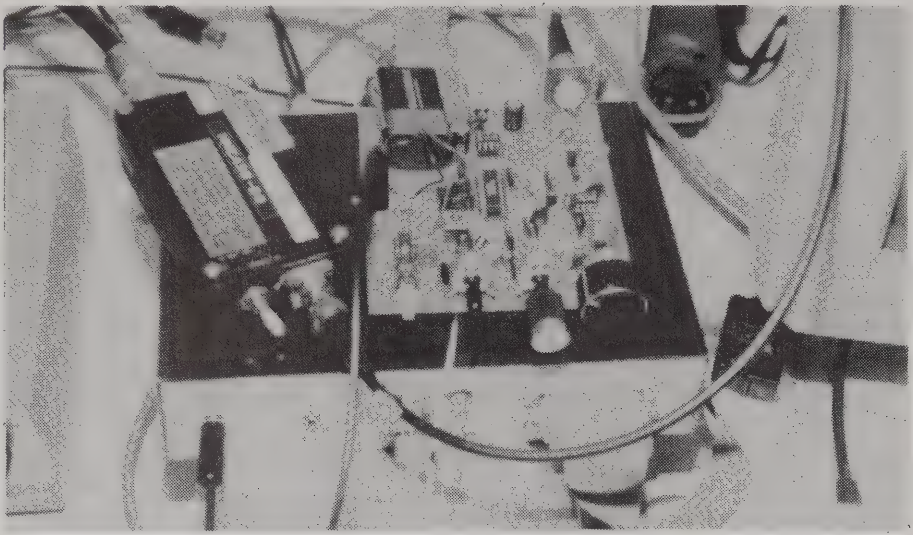

Fig 3: Photograph of the complete system

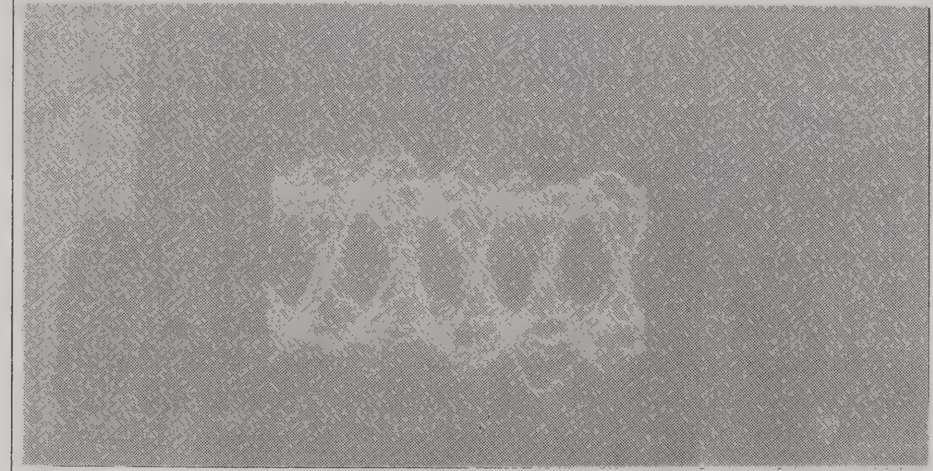

Fig 4: Oscilloscope eye pattern of received signals from UO-14.

regulator is that you can replace the battery with an external 12 VDC supply and not change the receiver's tuning range or performance. Turn on the receiver and measure the voltage at the + terminal of C14. It should read +6 VDC.

d) With the tuning control set at midrange, readjust the slug in L3 to move the center of the tuning range to the predicted output frequency of your 70cm converter when receiving UO-14. If your converter has an input range of 435 to 437 MHz and an output range of 28 to 30 MHz, UO-14's 435.070 downlink would be received as 28.070 MHz. Follow the Ramsey manual instructions for tuning L3. Use of a frequency counter is the easiest method. Set the local oscillator frequency 10.7 MHz higher than your desired listening frequency (for the example given, that frequency would be 38.770 MHz). You can determine the total available tuning range by measuring the LO frequency at each end of the tuning control range.

Once you have made the above modifications, it is probably best to listen for UO-14 with an oscilloscope connected to the modem for the first few passes. This will allow you to get the feel of receiving UO-14. It will also allow you to fine tune the L3 slug, if necessary.

Results and Observations

This simple, inexpensive setup has provided adequate performance on UO-14 for several months. It does appear to be more likely to lose data from fades than my modified Kenwood TS430S , but for less than 4% of the cost of the Kenwood, it is quite satisfactory.

I mentioned earlier that, on the Kenwood, it is possible to tell when UO-14's signal is present by the "noise" that breaks a high squelch setting. The Ramsey's squelch doesn't seem to work that way. Fiddling with its squelch settings never did provide a satisfactory setting where the presence or absence of noise would reliably indicate whether UO-14 was present. The 'scope on the modem is best, but watching the CON light on the TNC also works. Incidentally, since the audio section of the Ramsey receiver serves no purpose for UO-14 reception, leaving the audio level all the way down will prolong battery life. And save your ears. The UoSAT is not pleasing to the ear.

An unexpected benefit of this arrangement is that, once you find the proper tuning control setting, many passes can be monitored without retuning! The modified receiver is broad enough to catch almost the whole pass. The data at the ends of the pass may be a little ragged, but not too bad. There is no hard and fast rule for how to set up the tuning; just try it. Once you have some experience with this arrangement, you may want to mark the tuning knob with two settings; one for the first half of the pass and one for the second. Simply retune in the middle of the pass.

Sometimes during a pass a fade will cause loss of data. The normal reaction is to start tuning around until data is re-acquired. Suppress the urge - the data will usually start back after the fade has ended.

Food for Thought

This is definitely not the last word on this subject, but rather is designed to pique the satellite user's curiosity. Sometimes satellites are seen as such high-tech devices that only high-tech (and high priced) equipment will provide suitable ground station performance with them. We tend to overlook some of the simpler solutions. This is one of those simple, experimenter's solutions that is inexpensive enough for anyone to try. I would be interested in other experimenter's results and new ideas on this subject. Good luck!■

References:

1. *"A High Performance, Easy to Build 432 MHz Transverter- Parts 1 and 2"* by Ed Krome KA9LNV, QST, August and September, 1991.
2. *"A Tale of Two UoSATs"* by Jeff Ward, QST, July 1990, p 62.
3. *"Ask a Simple Question..."* by Jeff Ward, QST, August 1990, p 70.

Sources of supply:

70 cm Receive converter:
Spectrum International (Microwave Modules)
P.O.Box 1084
Concord Mass 01742
(508) 263-2145

10 Meter FM Receiver kit, Model FR 10:
Ramsey Electronics, Inc.
793 Canning Parkway
Victor NY 14564
(716) 924-4560

9600 baud modem and TNC
(PacComm NB 96 and TNC 200):
PacComm Inc.
4413 N. Hesperides St.
Tampa FL 33614-7618
(813) 874-2980

More on “ An Alternative Approach to 9600 Baud Satellites”

by Hanspeter Nafzger, HB9AQZ
Obstgartenstr. 6
CH-8302 KLOTEN
Switzerland

Ever since Ed Krome, KA9LNV published his article (AMSAT Journal Sept./ Oct. 1991) I was not only fascinated by his work, but also eager to duplicate it. The main reasons behind my motivation were, a) I’m looking for a small portable station for our summer home in the Alps, and b) to prove that you don’t have to be rich and need sophisticated equipment as told by some people.

Between 1992, when the first article was published, and 1994, additional 9600 baud satellites became available, which necessitate a few changes to the original concept. In particular, I wanted to add a frequency display, which allows for easy tuning of the greater frequency spread required in order to receive KO-25 at the high end. (Tuning at the upper end gets a bit tricky due to the slope of the tuning diode.)

Analyzing Ramsey’s AFC circuit together with the technical data sheets from the MC3359, I found that the AFC output at pin 11 can be used for a center-frequency display; a great help to offset the doppler shift.

Fig. 1 shows a block diagram from the antenna to 9600 baud modem. For the downlink, various antennas can be used, fixed or steerable, this all depends on how much data one is willing to capture - or lose. A good preamplifier is always

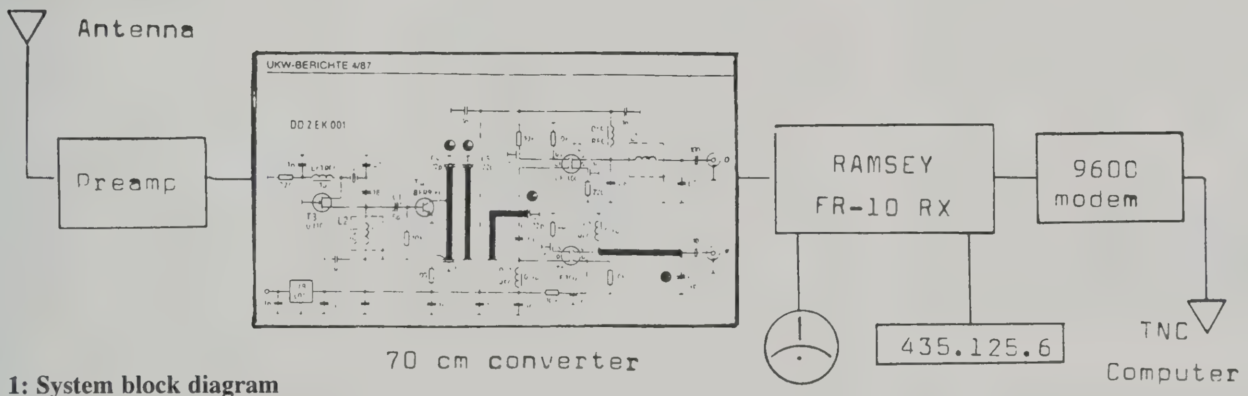

Figure 1: System block diagram

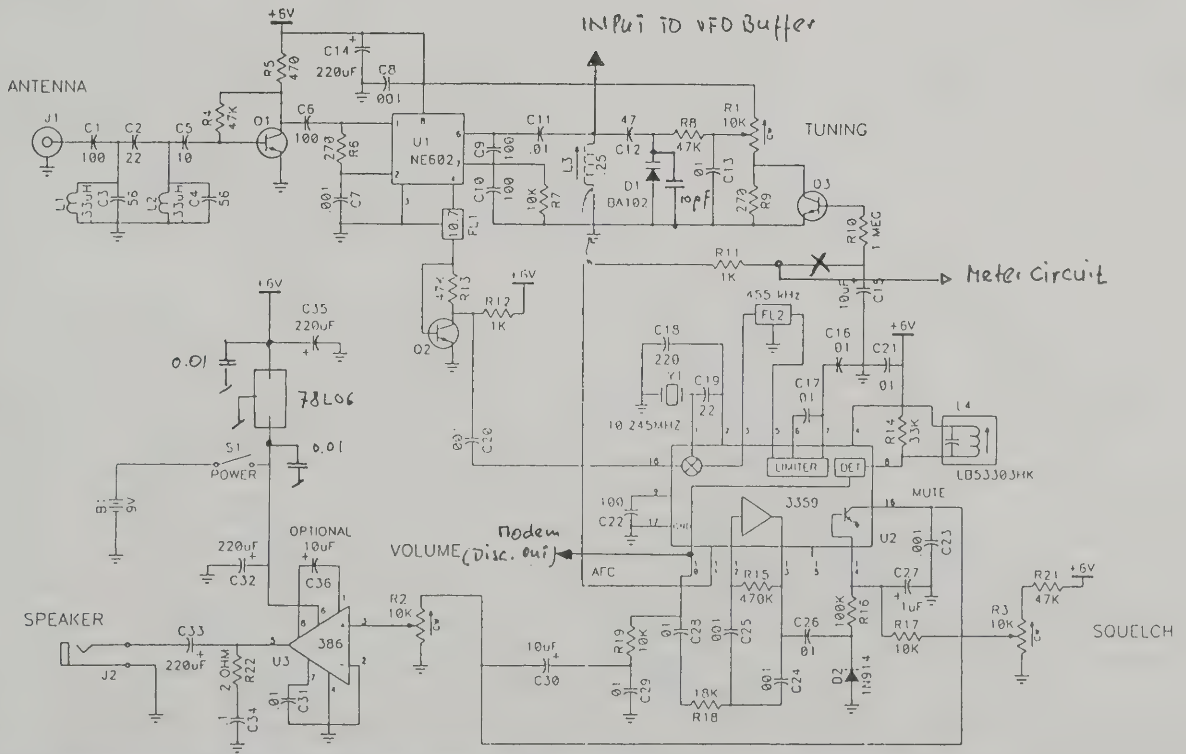

Figure 2: FR-10 Receiver Schematic Diagram (reproduced with permission of Ramsey Electronics, Inc.

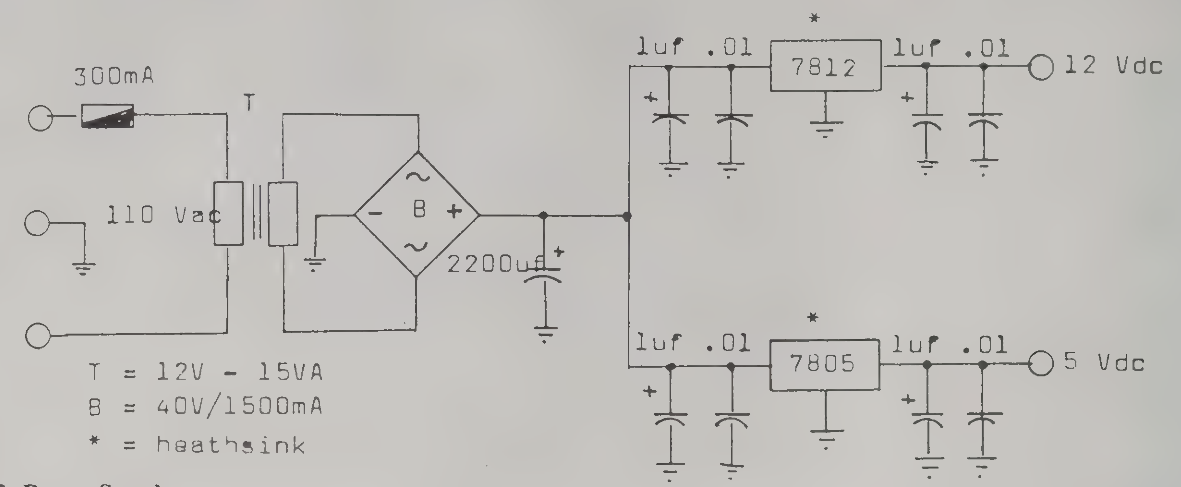

Figure 3: Power Supply

needed, they are readily available from different sources. For those of you wanting a tiny SMD-version, I would like to mention ON6UG's design, published in the AMSAT-DL "Journal" Sept./Nov.93 (pcb's and parts are made available through the AMSAT-DL Warenverkauf. (1) The 70-cm converter is a well proven circuit, designed by Wolfgang, DJ8ES, and is available as a complete kit, including all parts, connectors and case [5"* 3"* 1.5"] from UKW-Berichte, Germany. (2)

Fig. 2 shows the basic Ramsey FR-10 receiver with the modifications and connecting points for the modem, counter and meter circuit. Please note that the current release of the FR-10 circuit differs slightly from the one published by KA9LNV. Also note that the original AFC circuit is disabled (X) when the center-frequency circuit is used!

Making the Modifications

Before you start, read Ed's original article. Contrary to his advice, start with the following modifications before building the kit.

Voltage regulator - R20 and Q4 are replaced with a small voltage regulator (78l06), a must for a stable tuning voltage source. Additional capacitors (.01) are placed near the in- and output of the regulator. By carefully comparing the parts placement sheet with the pcb, one easily finds the positions where to drill the holes needed for the parts.

Tuning range - To cover 435.000 MHz to 436.000 MHz, the basic receiver must be capable to tune between 28.0 MHz and 29.6 MHz. (The actual frequency of the oscillator is 10.7 MHz higher, 38.7 MHz to 40.3 MHz). A 10-pF capacitor (polysterne) across the tuning diode (D1) is all what's needed to cover the said frequency range.

Modem connection - Solder a shielded cable to pin 10 (MC3359). As a rule, shielded cables should be grounded at one side only to prevent ground loops. Take the nearest ground at the pcb. The other end is connected to the modem.

Additional Features

Now it's time to take a break and make a few decisions about how many of the add-on's you are planning to build. (Display, center-meter, power supply.) Once you made up your mind, start looking for an appropriate case! Even if you don't plan on using any of the add-on's, at least replace R1 (10k potentiometer) with a precision 10-turn potentiometer, even better, use a 10 to 1 reduction gear in front of the potentiometer.

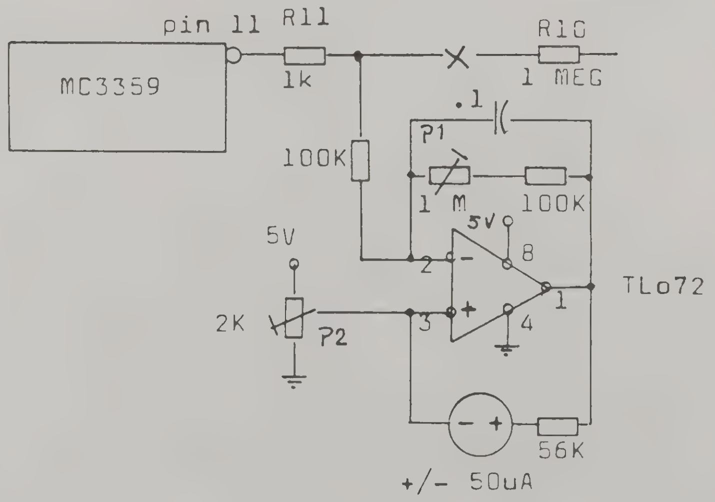

Figure 4 Center Frequency Display

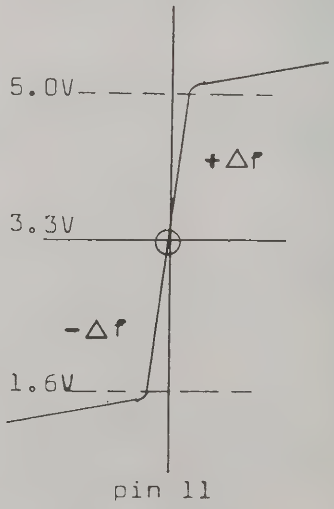

Figure 5 AFC Response

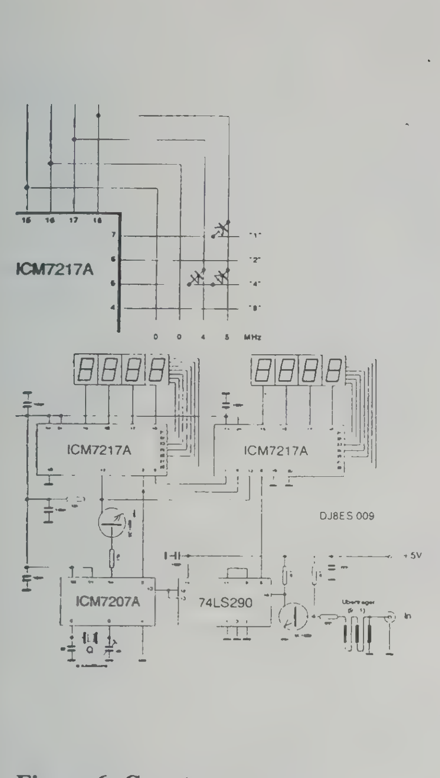

Figure 6: Counter

Power supply - Since the counter section needs 5Vdc and the receiver 12Vdc, I made a small pcb for the 2 voltage regulators (see Figure 3).

Center Frequency Circuit- I used the TL072 because it was available from the junk box, any other similar op-amp will work (see Figure 4). P1 sets the sensitivity of the circuit, P2 is used to set the reference voltage (3.3Vdc) for the center frequency. Figure 5 shows the AFC response.

Counter- The counter is also based on the works of DJ8ES, (4) who kindly supplied me with the pcb's (counter and display) The original circuit is described in the Intersil applications handbook; however the chips are now sold under the name Harris and are available from different sources.

A nice feature of this circuit is that it can be programmed for almost any off-set. To display the frequency with 100 Hz resolution, seven digits are needed. It's however up to the individual user to decide what's best for him.

Offset- To display 435.000.0, one must subtract 38.700 (the oscillator frequency for 28MHz) thus giving an off-set of 396.300. In other words, with no signal at the input of the counter, the display must show the programmed off-set value. The 2 decimal points are connected to 5Vdc with 150 ohm resistors. (Additional corrections for the exact converter frequency can also be included in the off-set value). For the actual off-set value, several diodes (1N4148 o.s.) are soldered directly onto the pcb.

VFO buffer amplifier - The basic counter is designed for an input of 5dBm, which of course is not available from the NE602 oscillator-mixer. Having built many VFO's, Figure 7 shows a proven design, which I used for this project.

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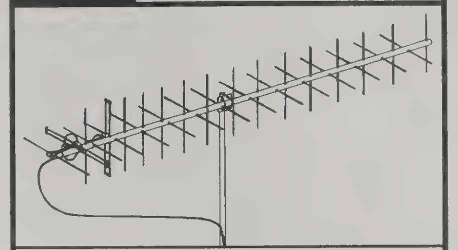

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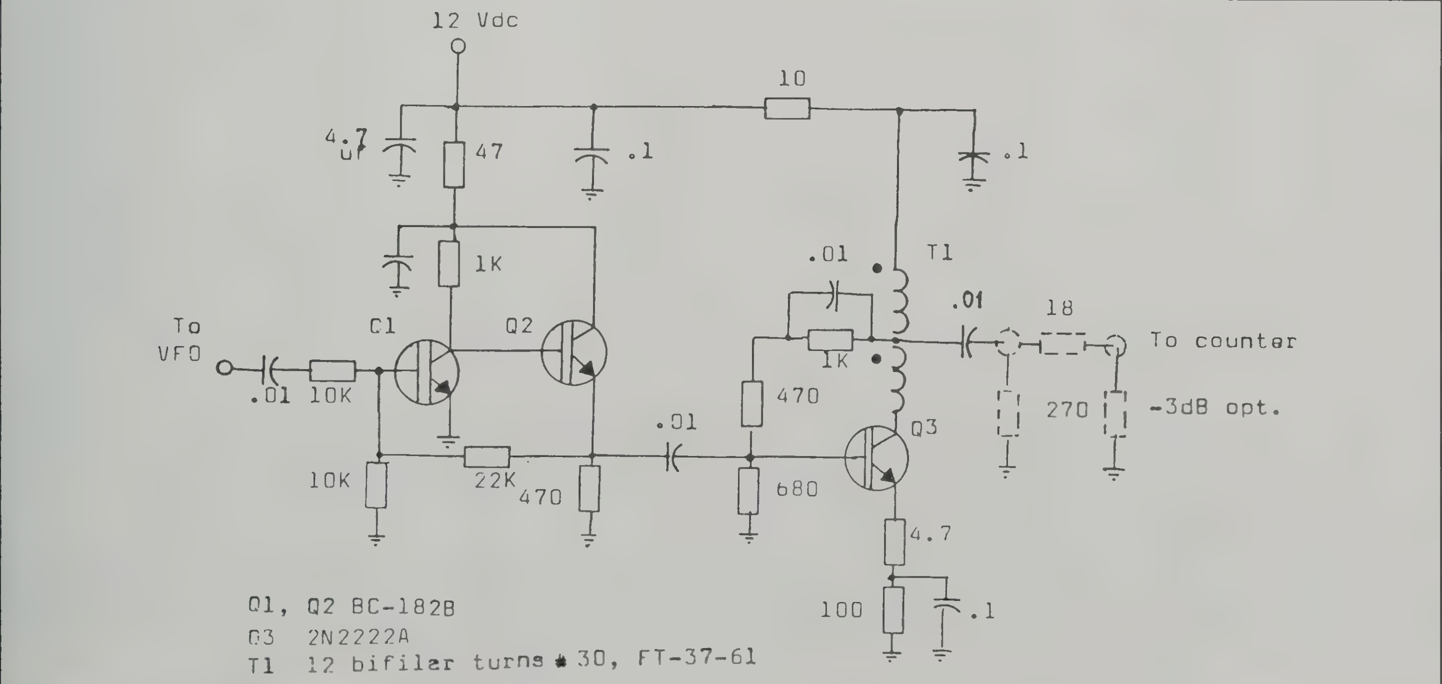

Figure 7: VFO buffer amplifier.

Final tuning - Since the frequency display is a counter, simply adjust L3 for the desired frequency coverage. Adjust P2 (meter circuit) for a reference of exactly 3.3Vdc. Initially tune L4 (quadrature coil) as described in the manual. Fine tune L4 with a signal generator, or use a satellite, until the meter is exactly centered when the signal is properly tuned. Don't retune P2! Slight variations in frequency (Doppler shift) will move the needle off-center. No other adjustments are required.

Operational Experience

Throughputs from all satellites (UO-22, KO-23, KO-25 & POSAT) are excellent and in no way fell short of any expectations. The contributing factors are the frequency display and the center-frequency meter. Further improvement might be possible by replacing the supplied filter (FL2) with a wider one, e.g. CFU455F. There are a few noticeable "birdies" caused by the counter chip, but luckily none of them coincide with a signal from a satellite. However, as a precaution, I can switch-off the display if deemed necessary.

A word of caution - The PCB supplied with the Ramsey kit shows REV 92D at the bottom. After the initial test, using a "handy" instead of a signal generator, (which would have saved the day) all looked well and I was very eager to make a "life" test with a satellite. To my great disappointment, not a single byte of data was received. Finally after doing what I should have done initially, I discovered a gap of 1/4" on the PCB, (near jmp 3) in the trace which connects R5 to 6Vdc for the preamplifier stage. (Q1) Bridging the gap with a short piece of wire solved the problem. I've advised Ramsey about this problem and I must assume that they will rectify the PCB accordingly.

Current Amateur Satellite Frequencies

Satellite	Callisgn	Uplink	Downlink	Type
AO-10		435.03-435.18 LSB/CW	145.975-145.825 USB/CW	Mode B Analog
AO-13		435.423-435.573 LSB/CW	145.975-145.825 USB/CW	Mode B Analog
AO-13		435.603-435.639 USB/CW	2400.711-2400.749 USB/CW	Mode S Analog
FO-20		145.9-146.0 LSB/CW	435.9-435.8	Mode J Analog
AO-27		145.85 FM	436.80 FM	Part-Time Repeater
RS-10		145.865-145.905 USB/CW	29.360 - 29.400	Mode A Analog
RS-12		21.21-21.25 USB/CW	29.41-29.4	Mode K Analog
AO-16	PACSAT	145.90, .92, .94, .96 FM	437.0513 SSB	1200 Baud PSK
DO-17			145.825 FM	1200 Baud AFSK/ voice
WO-18			437.104 SSB	1200 Baud PSK (img)
LO-19	LUSAT	145.84,.86,.88,.90 FM	437.1258 SSB	1200 Baud PSK
FO-20	8J1JBS	145.85,.87,.89,.91 FM	435.91 SSB	1200 Baud PSK
UO-22	UOSAT5	145.9, .975 FM	435.12 FM	9600 Baud FSK
KO-23	HL01	145.85, .90 FM	435.175 FM	9600 Baud FSK
KO-25	HL02	145.87 FM	436.5 FM	9600 Baud FSK
IO-26	ITMSAT	145.875, .90, .925., 95 FM	435.822 SSB	1200 Baud PSK
POSAT	POSAT1	145.975 FM	435.2777 FM	9600 Baud FSK

1) Frequencies shown are without Doppler compensation. For typical digital satellite pass the original signal will be about 8 kHz higher than what is shown.
2) WO-18 Webersat transmits experimental and image data and can be captured in KISS mode via PB or TLMDC.
3) Except for FO-20 the digital sats use a program suite containing PB/PG/PFHADD/PHS or WISP. The broadcast callsign (in PB.CFG) is the satellite's callsign with an SSID of -11. The connected mode callsign (in PG.CFG) is the satellite's callsign with an SSID of -12.
4) When in mode JD, FO-20 can be worked with any packet program. Connect to 8J1JBS. FO-20 currently alternates between modes JA and JD on a weekly basis. Check ANS bulletins for schedule.
5) AO-10 is no longer controllable but the transponder works when the satellite is in sunlight.
6) For AO-10 and AO-13, transmit LSB, receive USB. As transmitted frequency is increased the received frequency will decrease (inverting transponder).

Conclusion

The heart of the project is still the Ramsey FR-10 receiver kit, and with a few add-on's, the initial investment of $29.95 is well spent. If you, or your club, are looking for a worthwhile project, this one might be what you were looking for. And last but not least, nothing prevents you from building the missing equipment yourself. (TNC, Modem, Antenna etc), kits are readily available - at least in Europe - and as a courtesy to its members, I suggest that a "where-to-get column" be published in the "Journal" at regular intervals.

References

(1) Freddy de Guchtenaire, ON6UG,
AMSAT-DL Journal, Sept.Nov. 93
Parts: AMSAT-DL Warenvertrieb
Reinhard Richter, DJ1KM,
Lohfeldweg 10,
D-30459 Hannover
Germany

(2) 70-cm Converter kit:
UKW-Berichte
Postfach 80,
D-91081 Baiersdorf
Germany
When ordering specify the 435MHz to 28MHz version.

(3) Wolfgang Schneider, DJ8ES,
UKW-Berichte 1/1992

Parts List

1- 74LS290
1- ICM7207 (Harris)
2- ICM7217 (Harris)
2- BC108 o.s.
1- Xtal 5.24288 MHz
1- var. cap. 40pf
7- HDSP-5503 (common cathode)
1N4148's for I.F. off-set programming
9:1 transformer,
5 trifilar turns on small ferrite core

Satellite Orbital Elements

by Ray Hoad, WA5QGD

Satellite	**AO-10**	**UO-11**	**RS-10/11**	**AO-13**	**FO-20**	**RS-12/13**	**UO-14**
Catalog Num.	14129	14781	18129	19216	20480	21089	20437
Epoch Time	94328.80346848	94340.05398557	94339.11467096	94333.70699234	94338.80415905	94341.25504172	94338.26943105
Element Set	328	758	995	997	752	759	57
Inclination	26.7355	97.7815	82.9253	57.6540	99.0635	82.9207	98.5835
RA of Node	296.4176	346.7034	202.5013	217.5974	98.5992	243.0901	60.6695
Eccentricity	0.6023898	0.0012984	0.0010335	0.7247486	0.0540537	0.0029467	0.0011892
Arg of Perigee	230.1525	79.5633	273.3787	355.9625	313.2398	349.9641	53.4486
Mean Anom.	59.2733	280.7031	86.6186	0.6416	42.4758	10.0922	306.7786
Mean Motion	2.05880748	14.69279728	13.72345211	2.09726205	12.83227956	13.74050699	14.29866118
Decay Rate	-.00000090	.00000198	.00000032	-.00000472	-.00000056	.00000023	.00000022
Epoch Rev	8609	57554	37335	4948	22601	19241	25389
Satellite	**AO-16**	**DO-17**	**WO-18**	**LO-19**	**UO-22**	**KO-23**	**AO-27**
Catalog Num.	20439	20440	20441	20442	21575	22077	22825
Epoch Time	94338.24860431	94338.25628497	94338.23473232	94338.27129455	94342.21814385	94342.24632432	94338.19426940
Element Set	855	856	859	855	562	455	353
Inclination	98.5927	98.5940	98.5927	98.5946	98.4197	66.0817	98.6386
RA of Node	62.0707	62.4634	62.4282	62.7670	53.0513	275.5467	52.1637
Eccentricity	0.0012248	0.0012372	0.0012930	0.0013195	0.0008084	0.0014672	0.0009581
Arg of Perigee	52.9849	52.4590	52.8907	52.3994	124.3098	245.9130	71.1477
Mean Anom.	307.2445	307.7711	307.3455	307.8381	235.8854	114.0354	289.0739
Mean Motion	14.29919969	14.30060436	14.30033356	14.30132360	14.36947493	12.86289636	14.27643610
Decay Rate	.00000008	.00000016	.00000017	.00000024	.00000045	-.00000037	.00000002
Epoch Rev	25390	25392	25392	25394	17807	10917	6194
Satellite	**IO-26**	**KO-25**	**MET-3/3**	**MET-2/19**	**POSAT**	**MIR**	**HUBBLE**
Catalog Num.	22826	22828	20305	20670	22829	16609	20580
Epoch Time	94338.72342948	94338.69463345	94341.96274011	94342.36749717	94338.70321596	94341.41567219	94341.89537785
Element Set	351	330	207	856	345	862	571
Inclination	98.6395	98.6359	82.5488	82.5469	98.6365	51.6506	28.4703
RA of Node	52.7513	52.7478	149.8393	70.1342	52.7773	39.0960	200.0646
Eccentricity	0.0010110	0.0011116	0.0005949	0.0016599	0.0011036	0.0003264	0.0006181
Arg of Perigee	71.1912	58.9651	229.0745	22.7304	58.8053	349.2602	105.8034
Mean Anom.	289.0363	301.2615	130.9846	337.4565	301.4203	10.8263	254.3235
Mean Motion	14.27750020	14.28077886	13.04427726	13.84176763	14.28053758	15.58155983	14.90750917
Decay Rate	.00000021	.00000019	.00000044	-.00000039	.00000027	.00004241	.00000593
Epoch Rev	6202	3011	24555	22471	6203	50301	5533

Light Induced Satellite Spin Reversal

by Robert Reeves

Editor's Note: Robert Reeves took his project on microsat spin reversal to the Los Angeles County Science Fair in April of 1993 and won a first place in physics. In May of 1993 the project won First Place in the Applied Mechanics section of the California State Science Fair. Robert is now a Sophomore at U.C. Santa Cruz and is studying environmental science and engineering.

Unknown to many amateur radio satellite users, three Microsat satellites, Pacsat, Webersat and DOVE reversed their direction of rotation. Webersat reversed its spin in 1990-91, within a year of its launch. Pacsat underwent reversal a year later in 1992-93. DOVE was reported spinning in the original direction in early 1992 (1), but data collected in December 1993 shows it too has reversed its spin. I became aware of this spin reversal while studying the satellite data for a science fair project at my high school, Chaminade College Preparatory, in West Hills, California.

These satellites have essentially identical physical characteristics. They are all 23 cm cubes. The only exception, Webersat, is approximately two kilograms more massive and has a small compartment for additional instruments. They are in a sun-synchronous polar orbits about 800 kilometers above the surface of the earth.

All three satellites have components that are pertinent to the satellite's motion. These components affect the motion of the satellites in essentially the same way. The three components affecting the satellites' motion are the four magnets, the hysteresis rods, and the turnstile antenna (2).

One influence on the satellite's motion is the four bar magnets attached in each corner, parallel to the Z axis. These four magnets lock on to the magnetic field of the earth and cause the Z axis to follow the magnetic lines of flux of the earth. A second integral part of the satellite that affects its motion is the hysteresis rod section. These rods cancel unwanted motion on the satellite.

The final part on the satellites that contributes to the motion are the two sets of antennas. One is a single antenna parallel to the Z axis on the top or +Z surface. The second antenna, called the turnstile, consists of four antennas. One antenna protrudes from the bottom -Z axis of each of the sides at a downward angle 45 degrees from the Z axis. The turnstile type antenna is what controls the spin of the satellites about the Z axis. The elements of the antenna are painted white on one side and black on the other. The spin is caused by an imbalance of the pressures exerted by the photons reflected from the white and black surfaces. Since white reflects much more than black the satellite rotates away from the white side of the antenna. This rotation induces stability which helps maintain proper antenna orientation and a strong and constant radio signal. The rotation also helps to regulate the temperature on the satellite by exposing the entire surface to the sun. Finally, the rotation of the satellite extends the life of the solar panels by limiting their exposure time to direct sunlight.

The actual spin rate and direction and can be determined using data brought down from the satellite. After the data is brought down it is then converted into information that can be interpreted on a spreadsheet. This is done using TLM2SS or WOD2SS, two programs written for decoding the data received by the satellites. The data required to determine the motion of the satellite is the measurements of the electrical current that is produced by the panels on each face of the satellite. This data is found in Channels 26,27,28,29,2A and 2B of the TLM set. Once the data is brought into the spreadsheet it can converted into graphs. A peak on the graph occurs when a panel is directly facing the sun. (see Figures 1 and 2) By determining the order and frequency in which the peaks on the graph occur it is possible to determine the direction and frequency of the rotation of the satellite.

After determining that the satellites had reversed their rotational direction, it was important to decide why this happened. There were two possibilities: either an object had struck each satellite, or the reflectivity of

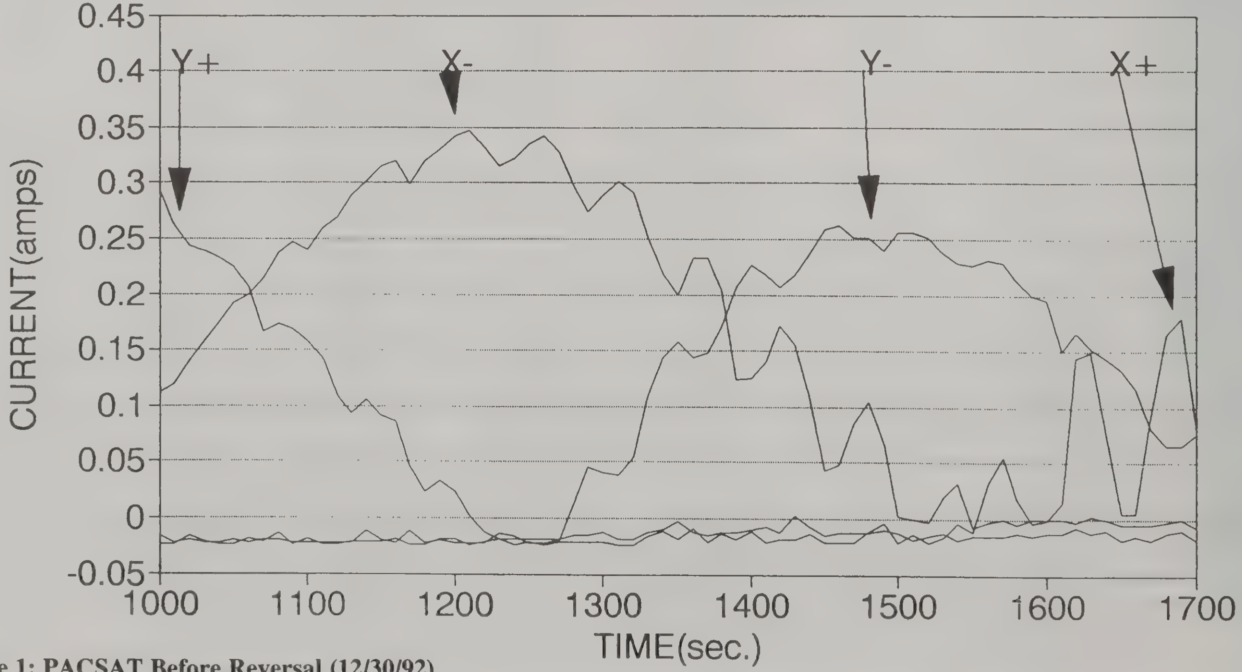

Figure 1: PACSAT Before Reversal (12/30/92)

the paint had changed so that the black side was more reflective than the white. I came to the conclusion that the reason for the reversal must be the deterioration of the paint. This is because of the long reversal time for each satellite. PACSAT required over five months to reverse and Webersat required over twenty months. With this idea in mind I searched for information pertaining to the paint.

It needs to be noted that the satellite is a "black box". It is impossible to retrieve the satellite to study it. Therefore all research must be done on materials that have experienced similar circumstances. The materials that were researched were Chemglaze Z306 paint and other similar kinds of paint. Research was conducted extensively on NASA's LDEF (Long Duration Exposure Facility) pertaining to the paint and many other protective coatings (3). From these studies, there are three key influences that could have caused the change in reflectivity and the spin reversal. They are: reaction with atomic oxygen, thermal expansion and contraction, and outgassing.

Atomic oxygen (AO) is one of the most destructive influences on materials in space. It attacked and damaged almost all the materials on LDEF including Teflon, aluminum, and most of the thermal coatings. Its effects include erosion of surfaces, a type of bleaching that actually lightened the paint, and it even caused the black paint to luminesce.

Another component of the synergistic attack on the paint was thermal expansion and contraction of the antenna blades. This constant movement weakened and deformed the paint leading to a loss of mechanical integrity and increased abrasiveness of the surface. This decreased the paint's ability to reflect.

The occurrence on the satellite that had the most profound effect was outgassing of the paint. Outgassing occurs when the paint sublimes from the surface of the blade. In the LDEF studies, the paint used on the Microsats, Chemglaze Z306, and its primer were found to be one of the major sources of outgassing. Deposits of the paint were found covering virtually all of LDEF with the majority on the trailing edge. On the microsats the trailing edge is the side of the antenna that is facing opposite the direction of rotation. Outgassing is important in relation to the paint change for several reasons. The major reason is the outgassed black paint from the leading edge (the side of the antenna that is facing toward the direction of rotation) vaporized and re-deposited on the trailing edge. This deposit formed a "nicotine" type stain. This stain considerably darkened the white. The final important fact about outgassing is that the majority occurred within the first thirty days in space.

In short, it appears that the white side of the antenna blades turned black and the black side turned white.

Areas Needing Further Investigation

As with any research, for every question that is answered five more can be asked. These are several of the questions I came to while doing this project.

PACSAT began its reversal much later than Webersat even though it is less massive. Does this delay have anything to do with the fact that PACSAT was launched spinning in opposite direction and spun backwards during the period of the most intense outgassing?

Another Microsat satellite, LUSAT, has not yet turned around. Is the reason that its spin has not yet reversed because of the difference in the antenna blade configurations?

Is there a correlation between the spin rate and the amplitude of the wobble on the satellites?

Acknowledgement

Assistance in this project was provided by Jim White and Tom Davis of AMSAT, Peter Yee of NASA and Dave Reeves, my physics teacher (and Dad). I would like to thank them for their help.

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2. White, Jim ,WD0E Microsat Motion and Stabilization (and Why We Care About It) AMSAT Space Symposium, 1990, p. 65

3. LDEF Spaceflight Environmental Effects Newsletter, LDEF Science Office, MS404, NASA Langley Research Center, Hampton, VA, 23681-0001.

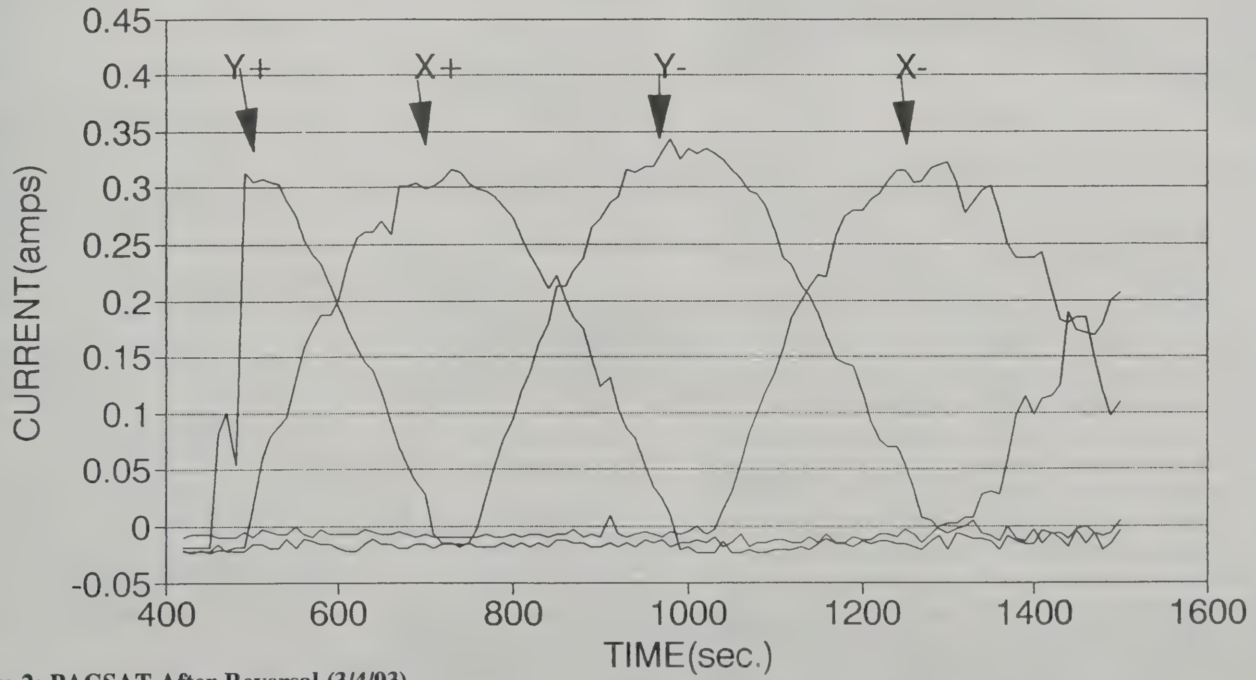

Figure 2: PACSAT After Reversal (3/4/93)

Heard on the Downlink

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L.L. Grace to Reorganize

Brooks Van Pelt is a true entrepreneur who has championed the commercial development of several products of great value to the amateur satellite community; most notably the Kansas City Tracker/Tuner and the DSP-12. However being a very small business is often not a particularly smooth road and the *Journal* has received occasional communications from AMSAT members who have had difficulty getting in touch with L.L. Grace. Recently, other business commitments have forced Brooks to substantially reduce his commitment to the business. While still providing technical support for its products, Brooks will no longer be involved in the day to day operations of the company. The Kansas City Tracker/Tuner has been turned over to John Emrich, who has, in fact, been heavily involved in its production for quite some time now. As of this writing, the word on the DSP-12 is that it is being discontinued. However, this situation is not necessarily permanent in that there are apparently preliminary discussions underway with some individuals who are interested in buying that portion of the business. Stay tuned...

In a related note, the first comprehensive firmware for the DSP-12 that was not written by L.L. Grace has been produced by an Austrailian amateur, VK2JJM. It has a number of enhanced features including a full implementation of the packet mailbox. The significance of this is not in the features of this flavor of firmware itself, but in the fact that the long-awaited third party development of DSP-12 firmware may actually be beginning.

Straight Key Night

Roy Soifer, W2RS, announces that once again Straight Key Night on OSCAR will be held on New Years Eve. Just call CQ SKN in the CW passband segment of any OSCAR satellite from 0000 to 2359 UTC on January 1, 1995, or answer a CQ SKN call from another station. OSCAR Zero (EME) contacts count too! Of course, all SKN operating must be done with a straight hand key.

It's entirely unofficial: no rules, no scoring and no need to send in an entry. However, if you care to send in a "best fist" nomination, please address it via packet to W2RS @ GB7HSN or W2RS @ WA2NDV, via Internet to w2rs@amsat.org, or via "snail-mail" to W2RS' callbook address. Last year's "best fist" nominees included W1NU and W6HDO, both two-time winners, and first-time winner WQ3Y.

AMSAT FTP Site

Under the direction of its new VP for Electronic Communications, Paul Williamson, AMSAT has greatly expanded its presence on the Internet. In addition to a World Wide Web page (more on this next issue) AMSAT-NA is now also sponsoring an ftp site where you can download the latest Keplerian elements, news materials, and software (such as the latest version of WiSP). However some folks are having problems reaching the AMSAT ftp site. Its host name, ftp.amsat.org, is an alias for the computers real name and your host's nameserver may not have learned this as yet. If you are having trouble reaching ftp.amsat.org try any one of the following:

ftp.qualcomm.com

192.35.156.5

I've found that while my host doesnt have the faintest idea where ftp.amsat.org is, it has no trouble at all locating 192.35.156.5. Tom Clark also informs us that the previous AMSAT ftp archive, tomcat.gsfc.nasa.gov, has not been in operation for almost two years.

Speaking of the AMSAT ftp site, G3RUH informs me that it now features error-free telemetry files captured from OSCAR 13. Look for the file a013.zip which contains the data. The file is overwritten with updated data on the first of each month. It can be displayed directly by P3C.EXE, which is available from w8gus@amsat.org, or other 400 psk telemetry software.

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SEE THE SPACE SHUTTLE VIDEO

Many ATV repeaters and individuals are retransmitting Space Shuttle Video & Audio from their TVRO's tuned to Spacenet 2 transponder 9. Others may be retransmitting weather radar during significant storms or home camcorder video. If it is being done in your area on 420 MHz - check page 501 in the 94-95 ARRL Repeater Directory or call us, ATV repeaters are springing up all over - all you need is one of the TVC-4G ATV 420-450 MHz downconverters, add any TV set to ch 2, 3 or 4 and a 70 CM antenna (you can use your same 435 Oscar beam). We also have downconverters and antennas for the 902-928 & 1240-1300 MHz bands. In fact we are your one stop for all your ATV needs and info - antennas, transceivers, amps, etc.
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MaryAnn (WB6YSS)

SATSKED Registration Continues to be Available from AMSAT

Wayne Roth, WA2N, continues work on his pioneering satellite program SATSKED. SatSked is a text-based, DOS satellite tracking/automation program for the communications programs PB/PG and SatLink. SatSked features built-in satellite AOS/LOS time calculation and a textual real-time display of up to 100 satellites. It interfaces to the Kansas City Tracker board and the TAPR Trakbox and will maintain PC and Trakbox clock accuracy up to one second per day. SatSked automatically uses new Keplerian elements as they are downloaded from satellites. Users need a registration number obtainable from AMSAT-NA in exchange for a donation of $25 or more. Once registered, new versions can be downloaded from the digital satellites. Funds derived from the distribution of SatSked will be contributed to the Phase 3D project.

G3RUH Releases Latest AO-13 Operating Sechedule

The following information was provided by James Miller, G3RUH:

The planned attitude schedule for Oscar 13 during 1995 is:

Date	Alon/Alat	Weeks
1994 Dec 19	180/0	9
1995 Feb 20	230/0	13
1995 May 22	180/0	10
1995 Jul 31	230/0	13
1995 Oct 30	180/0	9
1996 Jan 01	230/0	—

The mode schedule during periods of attitude 180/0 and 230/0 will be essentially as we have had during 1994. (Global groans). There is NO escape. The Sun aligns with the apogee/perigee line twice a year, and if we were to keep the attitude at 180/0, the solar panels would receive no sunlight then.

AO-13 Transponder Schedule

1994 Dec 19 - Feb 20 Alon/Alat 180/0

Mode-B	: MA 0 to MA 100	Omnis : MA 230 to MA 25
Mode-BS	: MA 100 to MA 130	
Mode-S	: MA 130 to MA 132	S beacon only
Mode-S	: MA 132 to MA 155	S transponder; B trsp. is OFF
Mode-S	: MA 155 to MA 160	S beacon only
Mode-BS	: MA 160 to MA 180	
Mode-B	: MA 180 to MA 256	

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12th Space Symposium and AMSAT Annual Meeting

Greg Jones, WD5IVD

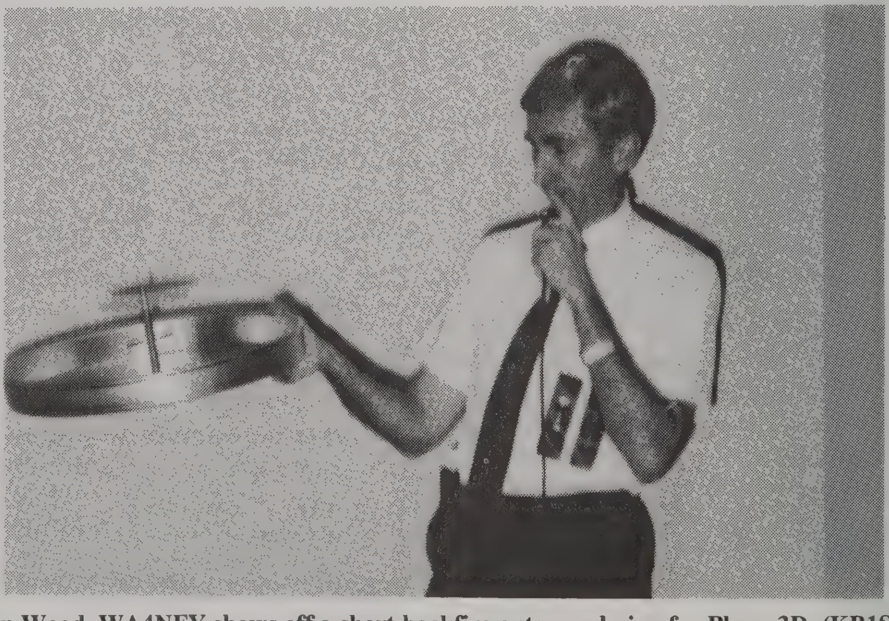
The 1994 AMSAT-NA Annual Meeting and Space Symposium was held at the Holiday Inn, Orlando International Airport, Florida on October 7-9, 1994. The turnout was great and lots of information was presented and exchanged regarding current satellite issues and the upcoming Phase 3D launch.

The conference kicked off on Friday at 1pm with various mission status briefings. Frank Bauer, KA3HDO, Lou McFadin, W5DID, and John Nickel, WD5EEV, discussed SAREX activity in 1994. Joan Freeman, KD4SRD, presented a SAREX Case Study. Dennis Wingo, KD4ETA, talked about SEDSAT1 and SEDSAT2 (the amateur radio satellite proposed for lunar orbit). Dan Schultz, N8FGV, presented a fascinating series of photos from the Hubble Space Telescope and the successful in-flight repair mission. Robert Diersing, N5AHD, presented a report on activities surrounding the recovery of the DOVE satellite. David Liberman, XEITU, presented a paper on using UNAMSAT, the new Mexican satellite which is still awaiting launch. Philip Chien, KC4YER, talked about launch opportunities beyond Phase 3D.

On Saturday, the conference was opened by Bill Tynan, W3XO, and Al Brinkerhoff, WB5PMR, the 1994 Symposium Chair. The first paper, by Professor Robert Twiggs, discussed an investigation of the integrated control of payloads and the Stanford SQUIRT Microsatellite Program. He finished the talk with a question about how AMSAT in the future would work with the various university programs. Peter Guelzow, DB2OS, discussed the reentry of OSCAR 13 and what the future holds during that process. Tom Clark, W3IWI, presented an informative talk on GPS technology entitled "Where Am I and What Time Is It?" After the first break, Walter Daniel, KE3HP, presented a paper on the use of star cameras for attitude determination of amateur radio satellites. Doug Loughmiller, KO5I/G0SYX, presented UoSAT: The Successful Evolution, which discussed how UoSAT (Univ of Surrey Satellite Program) has been successful in the past and what direction they are going in the future. Finishing the morning session, actually into the lunch break, were Greg Jones, WD5IVD, Bob Strickland, N5BRG, and Robert Diersing, N5AHD, who presented the latest information on the TAPR/AMSAT DSP-93 project. Much interest was shown in the design of the unit and future applications.

The afternoon session focused on Phase 3D. This session was packed with information and news on the satellite, which is currently being integrated in Orlando. Conference attendees had numerous opportunities during the weekend to take a shuttle

Paul Shuch, N6TX addresses a capacity crowd (they had to bring in more tables!) at the Saturday evening banquet (KB1SF photo).



Stan Wood, WA4NFY shows off a short backfire antenna design for Phase 3D. (KB1SF photo).

out to the integration facility and see the satellite in person. Bill Tynan, W3XO, opened with comments on the Phase 3D satellite and how it represented a new era for amateur satellites. Dick Jansson, WD4FAB, talked about the P3D mechanical and thermal design. Stan Wood, WA4NFY, talked about antenna designs for the spacecraft and passed around a number of full-scale models. Lyle Johnson, WA7GXD, presented information on the P3D IHU and RUDAK-U project. Peter Guelzow,DB2OS, talked about the P3D controller area network. Dick Daniels, W4PUJ, updated the current progress on the P3D Propulsion System. Tom Clark, W3IWI, updated current progress on the P3D GPS experiment. Doug Varney, WAlUVP, and Tom Clark, W3IWI, discussed the actual P3D GPS hardware. Bdale Garbee, N3EUA, Ron Luse, KD9KX, and Lyle Johnson, WA7GXD, discussed the P3D GPS computer system. Tom Clark, W3IWI, and Bill Hickey, WA5FXE presented information on P3D GPS antennas. Doug Loughmiller, KO5I/G0SYX talked about the current AMSAT-UK contributions to P3D.

The Saturday night banquet was well attended and Dr. Paul Shuch N6TX, gave a banquet talk on "The Search for Dark Matter." A number of plaques were presented after the banquet talk.

Early Sunday morning saw the Area Coordinators Breakfast. The Sunday morning session featured talks on satellite operating. Keith Baker, KB1SF, held a Beginners Forum. Robert Diersing, N5AHD, presented a paper entitled "Examination of AO-16 and U0-22 Activity". Dr. Paul Shuch, N6TX, talked about "Orbital Analysis by Sleight of Hand". Ed Krome, KA9LNV, discussed "Feeds for Mode S-Dish Antennas". Gould Smith, WA4SXM, presented a talk on "Beginners Guide to Radio Sputniks". Ned Stearns, AA7A, discussed and showed slides on their record-breaking field day operation. Roy Welch, W0SL and John Hansen, WA0PTV conducted a software forum that focused principally on groundstation software for the digital birds.

A packet satellite ground station was set up and working in the Continental Room for most of the conference. The ground station attracted a lot of attention since it was using WiSP. The DSP-93 was also being shown by TAPR. Mike Zingman, N4IRR,hooked up his PC to show off the alpha version of the scope program by Tom McDermott, N5EG. There was lots of interest in seeing the DSP-93 work during the weekend.

Al Brinkerhoff, WB5PMR congratulates Jack Littlejohn, WA9MTO winner of the grand prize, an Icom IC-281H. (KB1SF photo).

Overall, this year's AMSAT-NA meeting was a big success and another enjoyable weekend spent with other amateurs.

The following papers appeared in the conference proceedings:

Phase 3D, A New Era for Amateur Satellites, The Phase 3D Design Team

Phase 3D Critical Component Radiation Testing, Paul A. Barrow, VE6ATS

Contingency ACS Configurations for the AMSAT Phase 3D Spacecraft, Walter K. Daniel, KE3HP

Telecommunications Satellites from the World's Garage - The Story of the Amateur Radio Satellites, Keith Baker, KB1SF, and Dick Jansson, WD4FAB

Launch Opportunities Beyond Phase 3D, Philip Chien, KC4YER

The Re-Entry of OSCAR-13, James Miller, G3RUH

1993-94 Report on DOVE Recovery Activities, Robert J. Diersing, N5AHD

A SAREX Case Study - Getting Teachers Interested in Amateur Radio and Space Education, Joan Freeman, KD4SRD, and Philip Chien, KC4YER

UoSAT-3: Lessons Learned from Three Years of Serving the Development Community, Eric Rosenberg, WD3Q

A Long-Term Examination of AO-16 and UO-22 Activity Logs, Robert J. Diersing, N5AHD

UNAMSAT-l: An Operations Guide, David S. Liberman, XElTU

The 1994 Proceedings of the AMSAT-NA 12 Space Symposium are now available from AMSAT-NA Headquarters. The cost is $12 in US; $15 in Canada; $17 in Europe and $19 in Asia, Africa and Pacific. Please note that payment must be made in US dollars.

AMSAT wishes to express its gratitude to the following companies for the donation of door prizes at the 1994 Space Symposium:

Advanced Electronic Applications
- 1- ST-1 Satellite Tracker

American Radio Relay League
- 1- Antenna Book
- 1- Satellite Anthology
- 1- Weather Satellite Handbook
- 2- 1994 ARRL Handbook
- 3- 13th ARRL Digi Comm Conf. Proceedings
- 2- 1 yr. subscription to QEX
- Past issues of QEX

CQ Magazine
- 2- 1 yr. subscriptions

Cushcraft
- 1- AR-270 Dual Band Antenna

Down East Microwave
- 1- 435 No Tune Transverter w/ 15 watt PA
- 1- Mode S Downconverter w/ rx pre-amp

Henry Radio
- 1- Landwehr 145 Mhz Pre-Amp

Icom
- 1- 281H 2 meter mobil with 70 cm rx

Kiron Corporation
- 1- SatTrak IV Tracker/Tuner

L.L. Grace
- 1- K.C. Tracker/Tuner

M2 Enterprises
- 1- 436CP30 70 cm antenna

Joe Holman, KA7LDN (from Microsoft)
- 1- MS Complete Baseball for Windows
- 1- MS Visual C++ for Windows
- 1- MS Dionsaurs

Orlando Amateur Radio Club
- 1- 100 ft 9913 coax
- 1- Iso-Tip Butane Soldering Iron Kit

PacComm
- 1 PSK-1T Packet Satellite Modem

R. Myers Communications
- 1- SB-32 Mode S 2.4 Ghz Antenna
- 1- WinTrack
- 1- RealTrack
- 1- Oscar Satellite Report Subscription
- 1- Satellite Operator Subscription

SSB Electronics, USA and Germany
- 1- UEK-2000 SAT mode S down-converter

Yaesu
- Hats
- Frequency Charts
- World Maps

73 Magazine
- 2- 1 yr subscriptions

LUSAT-1 CW Beacon Transmitter, Gustavo Carpignano, LW2DTZ

VOXSAT Review, Gustavo Carpignano, LW2DTZ

The Stanford SQUIRT Micro Satellite Program, Christopher A. Kitts and Richard A. Lu

Investigating the Integrated Control of Payloads with Amateur Satellites, Christopher A. Kitts

Use of Star Cameras for Attitude Determination of Amateur Radio Satellites, Walter K. Daniel, KE3HP

Orbital Analysis by Sleight of Hand, Dr. H. Paul Shuch, N6TX

Dish Feeds for Mode S Reception, Ed Krome, KA9LNV

Monolithic Microwave Integrated Circuits at S-Band, Doug Varney, WAlUVP

A Major Field Day Satellite Operation, Ned Stearns, AA7A

Arctic HF Satellite Radio Propagation Studies, John Branegan, GM4IH

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Minutes of the AMSAT Board of Director's Meeting held October 9-10 in Orlando, Florida.

Transcribed by Bill Hook W3QBC

The meeting was held at the site of the 1994 Annual AMSAT Space Symposium, the Holiday Inn, Orlando International Airport, Florida. Members of the Board of Directors (BoD) in attendance were Bill Tynan W3XO, Dick Daniels W4PUJ, Tom Clark W3IWI, Junior DeCastro PY2BJO, Andy MacAllister WA5ZIB, Bob Diersing N5AHD and Keith Baker KB1SF.

Others participating at various times included Martha Saragovitz Corporate Secretary, Perry Klein W3PK VP Government Liaison, Jan King W3GEY, Art Feller KB4ZJ Treasurer, Dick Jansson WD4FAB V.P. Engineering, Stan Wood WA4NFY Asst. V.P. Engineering, Frank Bauer KA3HDO V.P. Manned Space Programs, John Hansen WA0PTV AMSAT Journal Editor, Dennis Wingo KD4ETA SEDSAT-1 Project Manager, Peter Guelzow DB2OS AMSAT-DL, Paul Williamson KB5MU newly appointed V.P. for Electronic Communications, Mark Kanawati N4TPY, David Liberman XE1TU AMSAT- Mexico, Lyle Johnson WA7GXD P3D IHU/RUDAK-U Team Leader, Chuck Green N0ADI, Greg Jones WD5IVD TAPR President, and Dan Schultz N8FGV. Ray Soifer W2RS participated by telephone on October 10.

The meeting was opened by Bill Tynan at 1000 Sunday October 9. The minutes of the October 10-11, 1993 BoD meeting were accepted as published in the November/December issue of The AMSAT Journal. Bill said that decisions and key discussions would be recorded on tape which would be transcribed by Bill Hook. This same procedure has been used for the past several Board meetings.

Bill Tynan announced that the meeting would generally follow the agenda as previously transmitted to the Board members by E-Mail, with some modifications to meet various travel plans.

I. Auditor's Report

The audit of AMSAT's financial status as prepared by the accounting firm of Verkouteren, Auerbach, Olson and Co. was presented by Art Feller and accepted by a unanimous vote. The Board agreed to continue to use the services of the aforementioned accountants.

II. Publications

AMSAT Journal Editor John Hansen reported on the progress made during the past year. He noted that 20% more copies of the Journal are being printed now at a cost 25% less than the previous year. The subject of product reviews was discussed. In answer to a question John stated that he does not want the post of V.P. for Publications as long as he has the workload he currently has as Journal Editor. He said that he is actively seeking a volunteer to serve as Assistant Editor who can assume some of his present duties.

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The ST-1 controls everything. If there is a file you want to retrieve from a satellite, type the file you want into your computer and the ST-1 does everything for you while you sleep, work—whatever! Using satellites couldn't be easier.

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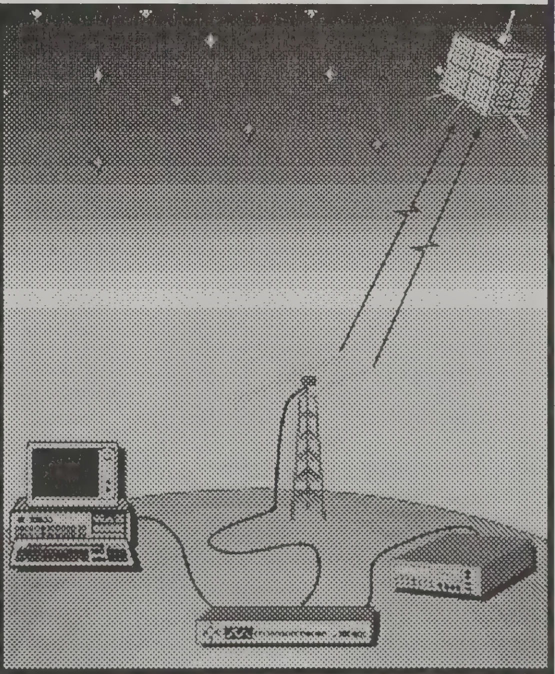
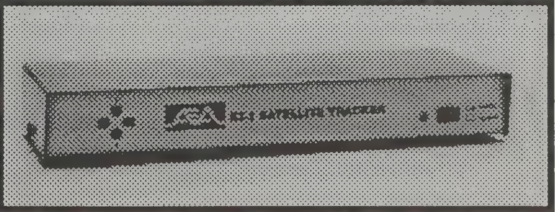




Bill Tynan, W3XO presides over a lively Board of Director's Meeting (W4PUJ Photo).

III. DSP-93 Project

The success of this joint TAPR/AMSAT project was described by Greg Jones. Sales of the first 100 units have been brisk and more kits are being produced. He emphasized that the approach has been that parts are not ordered until orders are received, which reduces up-front costs. Greg also said that software development has also been very successful with new features and modes being incorporated. Royalties will be donated to TAPR and will be shared with AMSAT. Income for each group may exceed $15K for the years 1994-95. It is planned that kits will be available for sale at both the AMSAT and TAPR booths during the 1995 Dayton Hamvention. Bill Tynan stated that he believes that AMSAT should support this, if necessary with advance funding.

IV. Field Operations

It was announced that Mike Crisler V.P. Field Operations is able to resume some of the work that had been handed off to Larry Brown after Mike's QTH suffered hurricane damage. One of these jobs will be to again update the list of Area Coordinators. An encouraging number of persons have volunteered in recent weeks to serve as Coordinators. Mike, as the overall manager, has emphasized that he will continue to need the assistance of Larry and others to fulfill the responsibilities of his post. Bill Tynan expressed the view that one of these tasks is knowing when and where the important hamfests are, what support is needed and finding volunteers to cover them.

It was noted that one of the major ham equipment manufacturers has become very interested in satellite operation and is seeking AMSAT's assistance in setting up dealer demonstrations. By unanimous vote, it was concluded that, while AMSAT can provide existing printed materials describing our organization, satellite operation and software, we will not jeopardize our 501(c)(3) status by providing the services of AMSAT representatives to help commercial companies in their sales promotions.

V. Other Satellite Programs

Dennis Wingo reported on SEDSAT-1 being constructed at the University of Alabama at Huntsville. This small satellite for primary use by amateurs will also serve as an educational tool and have an expected lifetime of 3-5 years. Its Mode A transponder is presently being tested on the ground and is performing well. Dennis sees opportunities for future educational activities using satellites of this type and asked for ground station support from AMSAT upon the launch which is expected in November 1996. Frank Bauer mentioned that the SAREX project may also work with Dennis on this program.

A proposal has recently been made that a conference be arranged to bring together representatives from AMSAT, universities and others working toward similar goals. Dennis offered to seek financial support from the Alabama Spacecraft Consortium and other consortia for the meeting and will maintain contact with AMSAT BoD members concerning planning. He also suggested that AMSAT contact NASA headquarters concerning the possibility of grant support for projects that are associated with universities. It was agreed that this avenue will be carefully explored. Bob Twiggs of Stanford University had also offered to host an AMSAT/University symposium.

Lyle Johnson reported on the ASU SAT being designed by The Arizona State University to detect dust particles in the exosphere 400 km above the Earth. This small spacecraft weighing approximately 5 kg and having a projected lifetime of two years has been offered a ride next October on the Pegasus mission. ASU has approached the Tucson amateur satellite group about using amateur frequencies for this spacecraft. In addition to the telemetry and particle data, it is proposed that ASU SAT carry a single channel amateur FM transponder resembling that on AO-21. It was concluded that before receiving AMSAT-NA's endorsement some issues need to be clarified. For example, is the scientific data to be collected likely to be useful to radio amateurs, will the data collected be in open format so hams can decode and understand it and will Amateur Radio operators control it in accordance with the requirements of FCC Part 97? It was the consensus of the BoD that if the above could be answered satisfactorily AMSAT would support the project. A full description of the ASU project will be sent to BoD members for study.

The University of Maryland is working on a project called SPARTAN that is to be deployed for a two day mission from an upcoming Shuttle flight. SPARTAN is to carry two meter and 70 cm equipment. Little else is known about the project except that its purpose has been characterized as educational. It was concluded that AMSAT will provide publicity for the short flight as details become known. The builders have been referred to Perry Klein for advice on licensing.

VI. AMSAT E-Mail

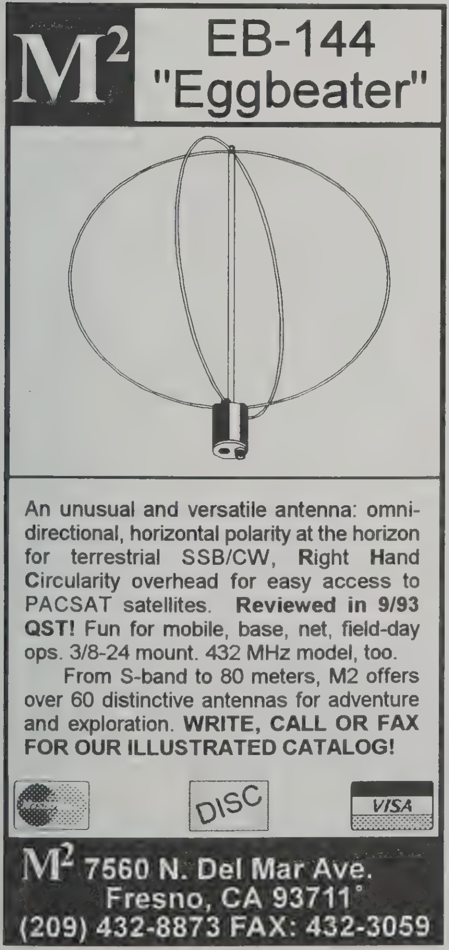
Paul Williamson reported that amsat.org has been running reliably for over two years, and now has over 1000 users. Messages are being read by a wide audience with Internet and commercial connections. A vote of thanks was afforded to Paul for this valuable contribution.

He told about a powerful extension of the Internet called the "World-Wide Web" that is capable of interfacing with sources including not only text, but photos, movies, audio and hypertext documents. This can serve as an on-demand magazine or as a library. As such, it could be used to provide a source for AMSAT archival material. He offered to establish such a capability and make it available to AMSAT at no cost to the organization. The Board accepted this offer with thanks.

Tom Clark told of the physical constraints represented by the present amsat.org equipment installation. On several occasions it has run out of disk space and there is a need to improve the file server capability. Although funds had been appropriated in the recent past to upgrade the amsat.org facility, they have not yet been spent pending decisions on the long term needs of the system. Bill Tynan announced that a new accounting category titled Electronic Publications is to be created and he appointed Paul Williamson as V.P. for Electronic Communications. A motion was made and passed unanimously to "add to the budget the sum of $5000 for equipment purchases and maintenance expenses for the new Electronic Publications Department".

VII. SAREX

Frank Bauer displayed the first draft of a new publication titled "SAREX Guide for School Group Coordinators" aimed at the teachers and technical coordinators involved in contacting the space shuttle. The final draft will be sent to Martha Saragovitz for incorporation of photographs. She will then send it to the printer. Frank stated that annual revisions are planned. He also reported that the SAREX Forum held at this year's Dayton Hamvention was well received and expressed his appreciation to Keith Baker for his valuable contributions to this event. He said that a SAREX meeting was held in Houston during August to discuss the past year's missions. In general, these were deemed as being very successful with Amateur Radio operations benefiting greatly by the cooperative spirit of the astronaut hams. A proposal has been submitted to NASA suggesting how best to proceed with this activity in the future. BoD members received a copy for their comments.



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Frank submitted recommendations to the BoD concerning proposed changes in the frequencies used during SAREX missions. Although the frequencies coordinated with the ARRL in 1992 appeared to have alleviated terrestrial concerns in the U.S.A., the European ham community has reported continuing difficulties hearing both Shuttle and MIR, because of heavy terrestrial use of 145.55. A recommendation to this effect has been received from the IARU Region 1 VHF Committee.

After studying the available alternatives, Frank presented the following proposed new frequencies and other recommendations:

1) Voice operation worldwide,

Downlink: 145.84 MHz Uplinks: 144.49, 144.47 & 144.45 MHz

2) Packet operation worldwide,

Downlink: 145.84 MHz Uplink: 144.49 MHz

3) A downlink frequency of 145.81 is suggested for future use to augment 145.84 MHz if that should become necessary.

4) It was also suggested that a downlink of 145.80 and an uplink of 145.20 might be used in Region 1 (Europe & Africa) to provide a 600 kHz split pair.

Frank further said that the above frequency recommendations do not preclude SAREX from operating simplex, if required. For such operation, frequencies that would minimize contention with other users, such as 144.49, 144.47 and 144.45, might be used.

The AMSAT V.P. for Manned Space Programs will continue to work with the ARRL, and the digital community in the U.S.A., as well as with AMSAT organizations and IARU officials internationally, to coordinate the above, or other frequencies. The Board suggested that, in addition, global coordination of all non-confidential SAREX frequencies for possible future operation in the 15- and 10 meter bands and 70 cm is highly recommended and should be pursued.

As a final item, Frank asked that approximately $500 be added to the yearly SAREX budget to purchase patches and plaques to award to those demonstrating achievements in the SAREX program. This amount was added to the Manned Space budget for consideration later in the meeting.

VIII. Phase 3D Progress Report

While the excellent progress being made at the Phase 3D Integration Facility was evident, Dick Jansson stated that there is much engineering and construction work yet to be done. Fortunately, a good fabrication team has been assembled through the immense dedication of Stan Wood and others.

Dick said that the proposed budget items will amount to approximately $300K notwithstanding the recent decisions relating to procurement of batteries and solar cells in Germany, which has saved approximately $100K. Offsetting this, price increases have been encountered with some items, such as separation pyros increasing from $25K to $40K. He said that seven units are required, three for engineering tests, and three for flight plus a spare. Dick indicated that, every effort will be made to save money, for example testing with pneumatic rather than explosive charges; but that some explosive tests will be required. He also reported that he is redesigning the separation system to achieve 120 joule separation energy and finding a way to build the ejection mechanism to obtain lower force with higher total energy through the use of multiple springs.

Dick also reported that the flight solar panels are nearly complete. He will go to Weber State University, after his return from Germany in mid October, to complete them and prepare them for shipping. A deadline of March 1995 was set for the receipt of the various transmitters and receivers and other electronic equipment to arrive at the integration Facility while other basic systems must arrive by the end of this year. A launch date in early April 1996 is still planned.

As for the SBS, Dick Jansson noted that an order with Weber State University in Utah has been placed at a cost of approximately $50K. The forgings will be received soon and machined shortly thereafter. Four frames are being machined. After receipt at Weber, there will be much high quality riveting required on the SBS to meet ESA specifications. Although Dick Jansson will go to WSU to help oversee this, he said that it may be necessary to obtain the services of an engineering consultant for a few weeks to provide additional expertise.

Jansson said that final details for mounting various pieces of hardware must be worked out soon. These include a 15-liter helium tank, the main and emergency batteries, and the plasma-jet motor. He said that a significant mass problem may exist. It is currently estimated that the spacecraft will be 80 kg heavier than specified. He said that he will be working on this potential problem. Jansson noted the need for the donation or loan of several pieces of test equipment plus a power conditioner for use at the facility. He said that the clean room has been installed and is functioning satisfactorily. Dick ended his presentation by noting that, although there have been some problems in finding volunteers with ability as well as enthusiasm to work at the facility, we have been fortunate to find a few people willing to work productively and for long hours.

Stan Wood noted that it needs to be determined when volunteers are needed to fabricate the wiring harness and perform other vital tasks. Approximately 3 month's work are required although it is expected that most persons will have only a few weeks available. It was emphasized that work should start on the harness by early December and that much of the effort might be scheduled over the holidays and other school holidays. It was noted that much of the harness fabrication involves crimping rather than soldering. Tom Clark suggested that a notice be posted on the AMSAT electronic bulletin board offering volunteers the opportunity to work on the spacecraft and mentioning dates when they would be needed. In addition, the announcement should appear in The AMSAT Journal and other appropriate publications. It should be stressed that either training or experience are required.

It was noted that Christopher Anderson N8BW had offered to provide a separate, wide- bandwidth microwave transponder for P3D. Among other applications, he said that it would be intended to serve as a continuously operating "scout jamboree on the air". Although the proposal sounded interesting to the BoD, it was the consensus that it is probably somewhat late to add another major system to the satellite. It was recommended that the matter be referred to Karl Meinzer.

Tom Clark said there is a need for additional support in circuit board layout capability for the GPS equipment and it may be necessary to hire a commercial firm to do this. The spacecraft's GPS receiver hardware will be running at the time of Dick's deadline with software suitable for ground testing. Interest has been expressed by university and other groups in the design of AMSAT's GPS receiver and this may lead to the possibility of licensing agreements that may help to offset some of the costs.

Lyle Johnson described the parts acquisition and budget requirements for the IHU, GPS and RUDAK systems. The combined memory requirements will require 1650 ICs that may cost as much as $25 each. Ways to reduce this cost are being explored. Tom Clark mentioned that he had received a donation of silicon on sapphire CMOS static RAM chips for the IHU. He described how radiation screening is being done in a medical facility in Canada.

With regard to P3D funding, Bill Tynan noted that this had been discussed at the General Meeting held on the previous day. He described a presentation he and Dick Jansson made before the ARRL BoD in July. They were advised that although there are probably sufficient funds to complete construction of the spacecraft, there is not enough money to launch it at the expected price. Bill noted that the League has already raised $200K for P3D. It was suggested that the ARRL BoD members should have the opportunity to visit the Orlando P3D integration facility. It was recognized that other contributors must be found to help meet the costs of the launch.

Jan King strongly recommended finding someone, with engineering expertise, particularly in electrical systems, to oversee spacecraft assembly and act as a general coordinator at the Integration Facility. He noted that such work would extend over many months. He also pointed out that one critical immediate task involves building the spacecraft wiring harness. He noted that this is a function AMSAT has had to pay for on a number of past satellites. Jan's words of wisdom were noted by the Board members and other concerned individuals present.

Junior de Castro offered the free use of a well equipped satellite testing facility near Sao Paulo, Brazil for environmental testing of the Phase 3D spacecraft. Dick Jansson expressed appreciation for this offer and said that he would take it up with Karl Meinzer during his upcoming trip to Germany.

Martha Saragovitz announced that any items donated to the project must be documented along with their estimated cost. This information is required by the AMSAT accountants and should be promptly submitted to her.

IX. Frequency Allocation Issues

Perry Klein reported that there is much pressure for space in the 2.4 GHz band and we will have to defend our interests. He said that AMSAT has filed comments with the NTIA opposing their plan to reallocate a major portion of the band from Government use to the "private sector". Amateur Radio currently shares these frequencies with Government on a Secondary basis, he said. Perry noted that we also filed comments with the FCC on its proceeding on the same matter. He observed that FCC had expressed disagreement with the NTIA specific plan. The NTIA plan does propose to retain the present Government status for the 2400-2402 MHz segment, but our comments emphasized that amateur satellites need far more than a 2 MHz bandwidth.

Note:

Shortly after the meeting, FCC released a Notice of Proposed Rule Making that would reallocate 2390-2400 and 2402-2417 MHz from the Amateur Service to the Fixed and Mobile Services. AMSAT will file comments in opposition and will coordinate the preparation of these comments with ARRL.

X. Long Range Planning

Keith Baker, V.P. for Strategic Planning, reviewed some of the events of the past year and then looked toward the future. At last year's meeting it was proposed that approximately 800 AMSAT members be surveyed for their interests, skills, expectations and talents. A strategic planning team would then evaluate the responses and make suggestions to the BoD relative to future desirable paths and projects. However, after receiving comments from valued advisors and before funds were spent the undertaking was deferred until further guidance could be received.

A lengthy discussion followed concerning how and whether we should plan for the future. The point was made that in most cases, the projects that are accomplished are those which interest the technical volunteers. Perry Klein noted that in the past most of our successful projects were self-generated by volunteers who wanted to do them, rather than at the direction of the AMSAT leadership. Tom Clark made a strong recommendation that we should attempt no projects that would require longer than 3 years to accomplish. He noted that it is difficult to keep people's interest for longer than that.

Dick Daniels noted that some demographic information about the membership would be valuable such as age distribution, what characterizes those who have joined recently vs. the early members, and what do the members want. Jan King noted past surveys of this type have shown that the activity people want is that which is currently

Continued on Page 30

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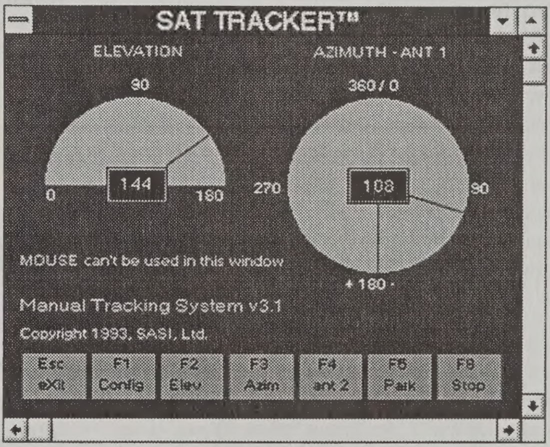

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the most popular activity; and the next most desired is that which was previously the most popular. Most of the new proposed activities, regardless of their merit, receive little enthusiasm. He further noted that AMSAT is the link between Amateur Radio and the aerospace industry and that trends in the latter are certain to have an impact on AMSAT's future; such as costs of launches and spaceframe construction. Dick Daniels suggested that a balance be achieved between the vision supplied by our leadership with the interests and wants of the general membership. Thus, the opinion of the group was that a survey should be done asking first "who are you?" and secondly "what do you want AMSAT to do next?"

Bill Tynan stressed that satellites are important to the future of Amateur Radio and that the nature of the hobby is changing. To some extent, the Internet may have taken over some of the things that amateurs like to do such as talking with people of similar interests. Tom Clark said it was important to continue to bring in new groups of people such as the packet radio community, those in universities and interested persons in other countries such as AMSAT-Mexico. There was agreement that because we are presently so involved with the construction of P3D it is difficult to see clearly where to go next. Returning to an emphasis on small satellites such as the MICROSATs might be a good choice.

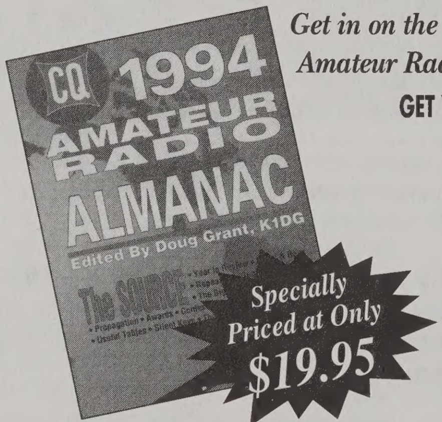
Keith Baker then reviewed portions of AMSAT's Articles of Incorporation, written 25 years ago and amended in 1989, In summary, they describe our purposes are to: 1) develop satellite technology to be used by radio amateurs, 2) encourage the development of skills and knowledge in the art of space communication, science and technology, 3) foster international goodwill and cooperation, 4) encourage use of the higher frequency amateur bands, 5) disseminate technical information derived from our experimentation and 6) pursue the above activities in a manner consistent with the maintenance of our 501(c)(3) status.

Keith proposed that strategies for the future should add the following goals: 1) expand AMSAT membership at a modest pace, 2) find innovative ways to launch Amateur Radio satellites into earth orbit and beyond, 3) explore ways to protect and market AMSAT-developed equipment designs and other intellectual property, 4) explore ways to increase the awareness of amateurs in the Amateur Satellite Service and in space science and 5) expand liaison activities with educational institutions and AMSAT partners worldwide who are engaged in projects related to Amateur Radio.

It was recognized that the AMSAT's future course cannot be fully determined at this time. Nevertheless, it was generally agreed that we should: 1) continue to support our educational activities, 2) recruit more younger people, 3) consider limiting future satellite construction to projects requiring no more than three years, 4) find ways to derive revenue from technology developed by AMSAT volunteers, consistent with our 501(c)(3) status, and 5) build on our role as mentors for other qualified groups interested in building Amateur Radio satellites. It was agreed that to assist the planning process Keith Baker would continue with his plan to conduct a survey focusing on the demographic profile of the membership. Bob Carpenter will be asked to assist in tabulating the results.

XI. Election of Officers

Bill Tynan asked for nominations for the offices provided for in the Bylaws (President, Executive Vice President, Vice Presi-



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dent Engineering, Vice President Operations, Corporate Secretary, Manager and Treasurer). The officers to serve until next year's Annual Meeting were elected as follows: President, Bill Tynan W3XO; Executive V.P., Keith Baker KB1SF; V.P. Engineering, Dick Jansson WD4FAB; V.P. Operations, Keith Pugh W5IU; Corporate Secretary Martha Saragovitz; and Treasurer, Art Feller KB4ZJ. Thus, Keith Baker replaces Ray Soifer W2RS as Executive Vice President. This is consistent with Ray's expressed wish not to be in line of succession for the Presidency, as required in the bylaws for this office. Ray has expressed a willingness to remain active as AMSAT's principal liaison with overseas AMSAT groups and the IARU as well as performing other tasks for which he is especially suited. Art Feller agreed to serve another term as Treasurer as a result of an earlier BoD decision to place the responsibility for the management of AMSAT's securities portfolio on the President. This will avoid the possibility of a conflict of interest involving the nature of Art's employment.

It was noted that the office of "Manager" is provided for in the Bylaws. It was observed that, since the position of paid General Manager was abolished by a Bylaws change several years ago, some of the duties of the this office have been performed by the unpaid President and some by Martha. In order to fill this office, required by the Bylaws, the Board voted to designate Martha as Manager.

Other offices are not provided for in the Bylaws and are created, eliminated and filled by the President as needed. Thus, as noted earlier, Paul Williamson was appointed to serve as V.P. for Electronic Communications. Bill Tynan said that he would make additional appointments soon.

XII. Guidelines for Amateur Radio Satellites

A draft document entitled "Guidelines for Satellites Utilizing Amateur Radio Frequencies" was presented for consideration. This document was the combined work of Ray Soifer, Art Feller and Bill Tynan. Its purpose is to serve as a guide to prospective builders of satellites that are intended to be identified as Amateur Radio satellites or which plan to use frequencies allocated to the Amateur Satellite Service; as well as a guide to AMSAT in assessing the nature of such proposals. Bill said that it is also the intention, once the document is approved by the Board, to submit it for consideration to AMSAT groups overseas and to the IARU.

Following the presentation the BoD unanimously passed a motion accepting the substance of the document and empowering a Drafting Committee to make appropriate editorial changes and complete the document. The committee consists of Art Feller, Robert Diersing, Ray Soifer and Bill Tynan.

XIII. IARU Amateur Satellite Coordination

Ray Soifer reported that the IARU Administrative Council has appointed Hans van de Groenendaal ZS5AKV to the newly created administrative post of IARU Satellite Adviser. They also created the post of IARU Satellite Frequency Coordinator and established "Terms of Reference" for this post. The IARU Satellite Adviser is to keep the IARU Administrative Council informed on all technical and operational aspects of the Amateur Satellite Service so that it can adopt appropriate policies to advance the interests of the Service before the International Telecommunications Union, and will supervise the work of the IARU Satellite Frequency Coordinator. For this year only, Hans was also empowered to appoint someone as IARU Satellite Frequency Coordinator; subsequent appointments will be made by the Administrative Council itself. Nominations are being sought for qualified persons to fill this volunteer position. Peter Guelzow was requested to ask Freddy deGuchteneire ON6UG if he would care to apply for this post under the Terms of Reference that have been established.

XIV. MICROSAT

Several requests have been received from amateur groups asking for access to the MICROSAT engineering data. In the past AMSAT has supplied some of these in exchange for a fee to cover part of the design costs. However, it has now become apparent that many of the electronic parts, called for in the design, are no longer available. Dick Daniels proposed that, henceforth AMSAT should provide the design information we have readily available to interested amateur groups with the understanding that they should not expect to receive advice beyond a referral to those associated with the design of the various assemblies. He further suggested that we should charge a sum only sufficient to cover our costs in making the data available. He mentioned a $5K as reasonable. It was noted that the MICROSAT design information we have readily available consists of mostly mechanical drawings on disks produced by Dick Jansson. Art Feller agreed to draft a contract defining this policy and submit it to the BoD for future action.

XV. Budget

The AMSAT-NA budget for 1995 was submitted by Bill Tynan and was approved unanimously with the additional items of funding for the new Department of Publications and providing the additional SAREX money as mentioned above. The budget reflects heavy spending for completion of the Phase 3D project and thus shows a significant deficit. It was noted that, if it becomes necessary to hire a P3D Integration Manager, the budget may require revision.

XVI. Other Matters

Junior de Castro suggested that next year's AMSAT Annual Meeting and Space Symposium be held in Brazil. Junior also noted that he has been elected President of the Brazilian Radio Amateur organization and is using sponsorship of a credit card as a means of rasing funds for the organization. He suggested that AMSAT might wish to investigate this as a way to raise funds to help support our activities.

Other sites suggested for next year's meeting included a return to Orlando, which might be attractive if the Phase 3D satellite is still to be there, and Tucson, Arizona. A decision will be made and announced soon.

XVII. "Ata-boys and Ata-girls"

Martha Saragovitz was thanked for her faithful service to AMSAT. Dick Jansson and Stan Wood and especially both Marys (their wives), as well as all of their co-workers were commended for their work in establishing the Phase 3D Integration Facility. The co-workers include Mike Peacock, Dick deVitorio, Gary Hauge, Frank Lavra, Phil Chin, Chuck Hennesy and others.

Tom Clark, Doug Varney and Frank Bauer thanked the many collaborators working on the Phase 3D GPS project. Among them are Roger Allshouse, Paul Barrow, Barry Buelow, John Conner, Eric Cottrell, Skip Cubbedge, Courtney Duncan, Bdale Garbee, Chuck Gollnick, Chuck Green, Peter Guelzow, Rick Hambly, Bill Hickey, David Hinderman, Dick Jansson, Lyle Johnson, Phil Karn, Randy Kohlwey, Ron Luse, Bryan McCoy, Brad Murray, Martha Saragovitz, Dan Schultz, Mike Schwaab, Don Spitzmesser, Dean Paschen, and Harold Price.

Past Director Haruo Yoneda, JA1ANG, was thanked for having come so far to attend the meeting and for offering his always-welcome wise counsel and advice.

XVIII. Conclusion

The meeting was concluded at 1:36 p.m. on Monday October 10. It was not officially adjourned as various items are to be handled by E-Mail as the need arises.

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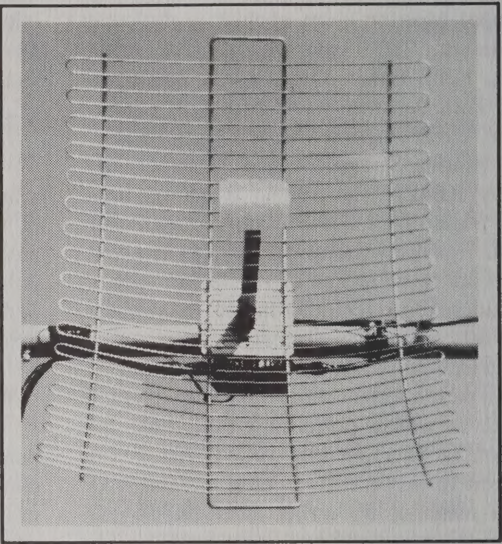

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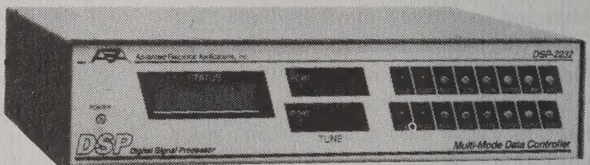
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